TM 11-2652

DEPARTMENT OF THE ARMY TECHNICAL MANUAL

CRYSTAL IMPEDANCE METER TS-683/TSM

DEPARTMENT OF THE ARMY • NOVEMBER 1953

TECHNICAL MANUAL

CRYSTAL IMPEDANCE METER TS-683/TSM AND TS-683A/TSM

TM 11-2652 CHANGES No. 1

DEPARTMENT OF THE ARMY
WASHINGTON 25, D. C., *2 November 1955*

TM 11-2652, 30 November 1953, is changed as follows:

The title of the manual is changed to read: CRYSTAL IMPEDANCE METERS TS-683/TSM AND TS-683A/TSM

CHAPTER 1
INTRODUCTION

Note. (Added) Crystal Impedance Meter TS-683A/TSM is similar to Crystal Impedance Meter TS-683/TSM covered in TM 11-2652, except for certain minor differences. All information in TM 11-2652 that applies to Crystal Impedance Meter TS-683/TSM also applies to Crystal Impedance Meter TS-683A/TSM except as indicated otherwise in this change.

1. Scope

* * * * * * *

b. (Superseded) Basic nomeclature followed by (*) is used to indicate all models of the equipment covered in this manual. Thus, Frequency Meter Set SCR-211-(*) represents Frequency Meter Sets SCR-211-A, B, C, D, E, F, J, K, L, M, N, O, P, Q, R, T, AA, AC, AE, AF, AG, AH, AJ, and AK.

2. Forms and Records

The following forms will be used for reporting unsatisfactory conditions of Army equipment:

* * * * * * *

c. DD Form 535, Unsatisfactory Report, will be filled out and forwarded to Commanding General, Air Materiel Command, Wright-Patterson Air Force Base, Dayton, Ohio, as prescribed in SR 700-45-5 and AF TO 00-35D-54.

* * * * * * *

Figure 2 caption (Superseded). Crystal Impedance Meter TS-683/TSM or TS-683A/TSM, with components of Standard Crystal Test Set AN/TSM-3.

3. General Description and Application

Crystal Impedance Meter * * * and various controls. **The front panel on the TS–683A/TSM contains fuse holder E2 and a spare fuse holder E23 (fig. 8.1). The TS–683/TSM does not have a spare fuse holder, and fuse holder E2 is located on the rear of the chassis.** The CI meter * * * (cycles per second). **The TS–683A/TSM also is provided with an external meter jack (J4) located on the rear of the chassis. This jack permits the connection of an external meter with a higher or lower voltage range than the panel meter.** A 5-foot r-f * * * with the meter. **The TS–683A/TSM is also furnished with Crystal Socket Adapter UG–683/U.**

7. Table of Components

Component	Required No.	Height (in.)	Depth (in.)	Length (in.)	Volume (cu in.)	Unit weight (lb)
*	*	*	*	*	*	*
Adapter * * * resistor	1	1¾	2¼	1½	5.9	.2
Crystal Socket Adapter UG–683/U (TS–683/TSM only).	**1**	**1¼**	**½**	**1½**	**.94**	**.2**
*	*	*	*	*	*	*
Total	**18**				**1,409.575**	**20.4**

Note. **This list is * * * of spare parts.**

8. Description of Crystal Impedance Meter

* * * * * * *

d. (Added) On the TS–683/TSM, fuse holder E2 is mounted on the rear of the chassis. On the TS–683A/TSM, fuse holder E2 and an additional spare fuse holder E23 are mounted on the front panel. An external meter jack (J4), mounted on the rear of the chassis, also is furnished on the TS–683A/TSM. The external meter is used during the test of crystals with drive voltage requirements so low that the result could not be accurately obtained on the panel meter.

9. Description of Minor Components

* * * * * * *

c.1. (Added) Crystal Socket Adapter UG–683/U (provided with the TS–683A/TSM only) is a receptacle for the HC–10/U-type crystal holder. This adapter may also be inserted into either the crystal socket on the meter panel or the crystal socket on anti-resonant adapter AR1.

d. A small box is provided to hold the 12 calibrating resistors, the variable calibrating resistor, the antiresonant adapter, and the crystal socket adapter.

* * * * * * *

11.1 Differences in Models (Added)

The external appearances of Crystal Impedance Meters TS–683/TSM and TS–683A/TSM are the same. However, some modification to improve operational features, relocation, and substitution of some of the minor components has been made on the TS–683A/TSM. Only the items on which a difference exists are listed in the chart below—

Component	TS–683/TSM	TS–683A/TSM
Telephone jack J4.	Not furnished.	Located on rear chassis.
Crystal Socket Adapter UG–683/U.	Not furnished.	Located in spare parts box.
Spare fuse holder E23.	Not furnished.	Located on front panel.
Fuse holder E2.	Located on rear chassis.	Located on front panel.
Meter shunt control R16.	1,000 ohms.	2,500 ohms.
Power cord W1.	Cord CX–112/U assembly.	Used with Connector Plug U–120/U.
Rf output jack J1.	Socket SO–239.	Receptacle UG–568/U.
Rf output plug.	Plug PL–259.	Plug UG–573/U.

12. Uncrating, Unpacking, and Checking New Equipment

* * * * * * *

b. Step-by-step Instructions for Uncrating and Unpacking Export Shipment.

* * * * * * *

(2) Cut and fold back the steel straps.

* * * * * * *

13. Installation of Equipment

The following steps should be followed in the installation of the equipment:

* * * * * * *

g. (Superseded) Remove the cap from fuse holder E2. The fuse holder is located on the rear of the chassis on the TS–683/TSM (fig. 8) or on the front panel on the TS–683A/TSM (fig. 8.1).

Check to be sure that a fuse (1-ampere) has been installed and that the fuse has not been operated.

* * * * * * *

Figure 4. The following note is added:

NOTE: ON TS–683A/TSM, FUSE HOLDER E2 IS LOCATED IN THE BOTTOM LEFT-HAND CORNER OF THE FRONT PANEL.

16. Table of Controls and Instruments

The following table lists the controls and instruments on the equipment and indicates their functions. Refer to figures 4, 8, **and 8.1** for illustrative identification of these controls and instruments.

Control	Function
*	*
Fuseholder E2	Holds 1-ampere fuse.
External meter jack J4	**Permits the use of an external meter with a lower voltage range for tests where the voltage measured is too low to be read accurately on the panel meter.**

18. Operating Procedure

a. Measurement of Series-Resonant Resistance.

* * * * * * *

(16) A slightly more accurate method of measuring the series-resonant resistance is to use four calibrating resistors and obtain two readings below **and two readings above** the crystal unit grid current meter reading; then plot the points on rectangular graph paper and read the effective series resonance from the graph.

* * * * * * *

21. Operation in Tropical Climates

In climates of * * * reasonably dry place. **For information regarding preventive measures and maintenance of Signal Corps equipment in tropical climates, refer to TB SIG 13 and TB SIG 72.**

Figure 7. The following note is added:

NOTE: ON TS–683/TSM, FUSE HOLDER E2 IS LOCATED ON THE FRONT PANEL AND EXTERNAL METER JACK J4 IS ADDED ON THE REAR CHASSIS.

Figure 7. Panel and chassis assembly, ***Crystal Impedance Meter TS–683/TSM,*** *top view, dust cover removed.*

Figure 8. Panel and chassis assembly, ***Crystal Impedance Meter TS–683/TSM,*** *bottom view, cover plate removed.*

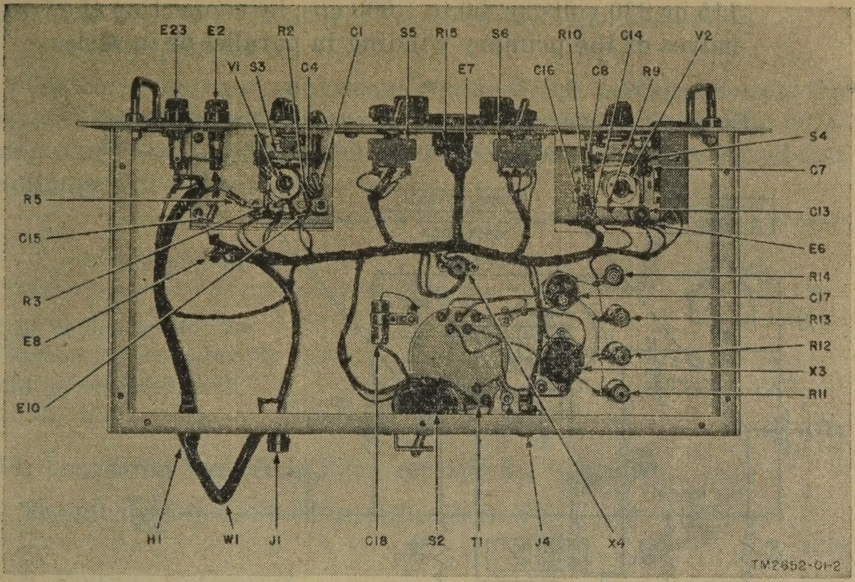

Figure 8.1. (Added) *Panel and chassis assembly, Crystal Impedance Meter TS–683A/TSM, bottom view, cover plate removed.*

Figure 9. Impedance Meters TS–683/TSM and TS–683A/TSM, lubrication points.

47. General

Crystal Impedance **Meters** TS–683/TSM **and** TS–683A/TSM **measure** the equivalent circuit parameters of a piezoelectric crystal in the frequency range of 10.0 to 140.0 mc. The CI **meters consist** of two tuned-plate, tuned-grid, variable-frequency oscillator **circuits (figs. 12, 12.1, and 13)** and a conventional power supply (fig. 14). Each circuit covers one of the specified frequency ranges, with **switch** S5 to permit the use of either circuit (figs. 11, 12, 12.1, and 13). The crystal under * * * the panel meter.

48. Functioning of Crystal Impedance Meters TS–683/TSM and TS–683A/TSM

a. General.

(1) The crystal impedance meter is essentially a tuned-grid oscillator circuit (figs. 11, 12, 12.1, and 13) in which the crystal unit to be tested is placed in the feedback path. The crystal unit * * * at antiresonant frequency.

* * * * * * *

b. Power Supply.

(1) The power supply * * * the ac line. VOLTAGE CHANGE-OVER switch S2 adapts the **unit** for operation on either

115 or 230 volts ac, 50 to 1,000 cps, by connecting the two halves of the primary winding in parallel or in series.

* * * * * * *

Figure 12. Low-frequency oscillator ***circuit, TS–683/TSM,*** *simplified schematic diagram.*

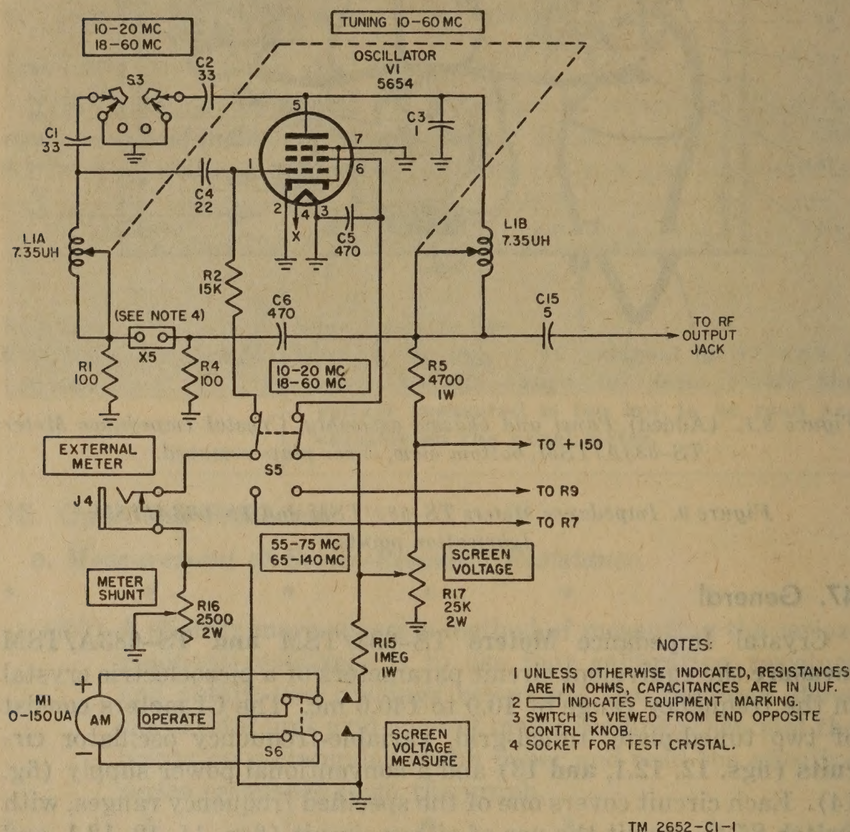

Figure 12.1 (Added) *Low-frequency oscillator circuit, TS–683/TSM, simplified schematic diagram.*

Figure 13. High-frequency oscillator ***circuit, TS–683/TSM*** *and* ***TS–683A/TSM,*** *simplified schematic diagram.*

49. General

a. The oscillator circuits (figs. 12, 12.1, and 13) use r-f pentode tubes type 5654 (V1 and V2) operating as class C amplifiers. The feedback path * * * C15 and C16.

* * * * * * *

50. Feedback Network

When an adequate * * * the circuit oscillates. The feedback path (figs. 12, 12.1, and 13) is through crystal socket X5 or X6. This socket also * * * 0.486-inch center-to-center spacing.

52. Tool and Test Equipment Required for Troubleshooting (Superseded)

The tools and test equipment required for troubleshooting the crystal impedance meter are listed in the table below. The common name and technical manuals associated with the required test equipment also are listed.

Tools and test equipment	Common name	Technical manual
Tool Equipment TE-113	Tool equipment	
Electron Tube Test Set TV-2/U	Tube tester	TM 11-5527
Multimeter TS-352/U	Multimeter	TM 11-2661

54. Localizing Trouble in Filament and B+ Circuits

Trouble in Crystal * * * rectifier tube V3.

* * * * * * *

b. Voltage to Ground.

Component	Terminal	Voltage to ground (dc)
*	*	*
V4	1 or 5	150 (tube lighted).
V1	1	—0.11 (S5 at low-frequency range; R17 fully counter-clockwise).
*	*	*
V2	1	—0.22 (S5 at high-frequency range; **R17 fully counter-clockwise**).
*	*	*

55. Troubleshooting Chart

This chart lists * * * proceed as follows:

* * * * * * *

c. Make simple direct preliminary tests such as listed below.

* * * * * * *

(4) Proceed according to the following chart:

Symptom	Possible trouble	Correction
*	*	*
3. No * * * socket.	*a.* Oscillator * * * oscillating.	*a.* Check * * * range.
	*	*
	h. **Contacts not making in J4 jack (TS-683A/TSM only).**	*h.* **Clean and adjust contacts.**
*	*	*

61. Alinement of Crystal Impedance Meter TS–683/TSM

Alinement of this * * * in chapter 4. Since the dial calibrations are intended only to be used as rough guides to the frequencies of the oscillators, no arrangement for picking up a standard frequency transmission from WWV **(Standard Frequency Transmission Station operated by Central Radio Propagation Laboratory, National Bureau of Standard)** is required.

*   *   *   *   *   *   *

b. Alinement of High-Frequency Tuning Dial. Position switch S5 * * * plate is positioned. If the dial cannot be made to log at the three frequencies, the sliding contacts on coils L2A and L2B may not be **tracking** correctly. If necessary, shift * * * check is made.

62. Equipment Required for Final Testing (Superseded)

After replacement and recalibration of any parts, the impedance meter must be given a final test before being returned to service. The test equipment required for final testing the impedance meter, with the common names and technical manuals associated with the equipment, is listed in the table below.

Test equipment	Common name	Technical manual
Frequency Meter TS–174/U	Frequency meter	TM 11–5044
Frequency Meter Set SCR–211–(*)	Frequency meter	TM 11–300
Electronic Multimeter TS–505/U	Electronic multimeter	TM 11–5511
Multimeter TS–297/U	Multimeter	TM 11–5500
Multimeter TS–352/U	Multimeter	TM 11–5527
Electron Tube Test Set TV–2/U	Tube tester	TM 11–2661

*Figure 15. Component terminal voltage and resistance diagram, **TS–683/TSM, only.***

Figure 17. Make the following changes on figure 17:

The following information is added:

At rotary switch S3: (SEE NOTE 3).

At rotary switch S4: (SEE NOTE 4).

At METER SHUNT R16: (SEE NOTES 5 AND 6).

The following notes are added:

5. ON TS–683A/TSM, METER SHUNT R16 IS 2,500 OHMS.
6. ON TS–683A/TSM, EXTERNAL METER JACK J4 IS CONNECTED BETWEEN METER SHUNT R16 AND TERMINAL OF SWITCH S5.
7. $\boxed{}$ INDICATES EQUIPMENT MARKINGS.

APPENDIX II

IDENTIFICATION TABLE OF PARTS

Rescinded

[AG 413.44 (3 Oct. 54)]

BY ORDER OF THE SECRETARY OF THE ARMY:

MAXWELL D. TAYLOR,
General, United States Army,
Chief of Staff.

OFFICIAL:
JOHN A. KLEIN,
Major General, United States Army,
The Adjutant General.

DISTRIBUTION:

Active Army:

CNGB (1)
Tec Svc, DA (1) except
CSIGO (30)
Tec Svc Bd (1)
Hq CONARC (5)
CONARC Bd (Incl ea Test Sec) (1)
Army AA Comd (2)
OS Maj Comd (5)
OS Base Comd (5)
Log Comd (5)
MDW (1)
Armies (5)
Corps (2)
Tng Div (2)
Ft & Cp (2)
Gen & Br Svc Sch (5) except Sig Sch (25)
Gen Depots (2) except Atlanta Gen Depot (None)
Sig Sec, Gen Depots (10)
Sig Depots (20)
POE (2)
OS Sup Agencies (2)
Sig Fld Maint Shops (3)
Sig Lab (5)
Mil Dist (1)
Units organized under following TOE:
11–7R, Sig Co, Inf Div (2)
11–16R, Hq & Hq Co, Sig Bn, Corps or Abn Corps (2)
11–57R, Armd Sig Co (2)
11–127R, Sig Rep Co (2)
11–128R, Sig Depot Co (2)
11–500R (AA–AE), Sig Svc Org (2)
11–557R, Abn Sig Co (2)
11–587, Sig Base Maint Co (2)
11–592R, Hq & Hq Co, Sig Base Depot (2)
11–597R, Sig Base Depot Co (2)

NG: State AG (6); Units—same as Active Army except allowance is one copy to each unit.

USAR: None.

For explanation of abbreviations use, see SR 320–50–1.

☆ U. S. GOVERNMENT PRINTING OFFICE: 1955—360517

TECHNICAL MANUAL No. 11-2652 — DEPARTMENT OF THE ARMY, WASHINGTON 25, D. C., *30 November 1953*

CRYSTAL IMPEDANCE METER TS-683/TSM

TAGO 2080B—Dec. 270482°—53——1

WARNING

HIGH VOLTAGE

is used in the operation
of this equipment.

DEATH ON CONTACT

may result if personnel fail to
observe safety precautions.

Be careful not to contact high-voltage connections or 115- or 230-volt input connections when working on or near this equipment. When working inside the equipment, after the power has been turned off, always short-circuit the high-voltage capacitors.

DANGEROUS POTENTIALS

exist in Crystal Impedance Meter TS–683/TSM.

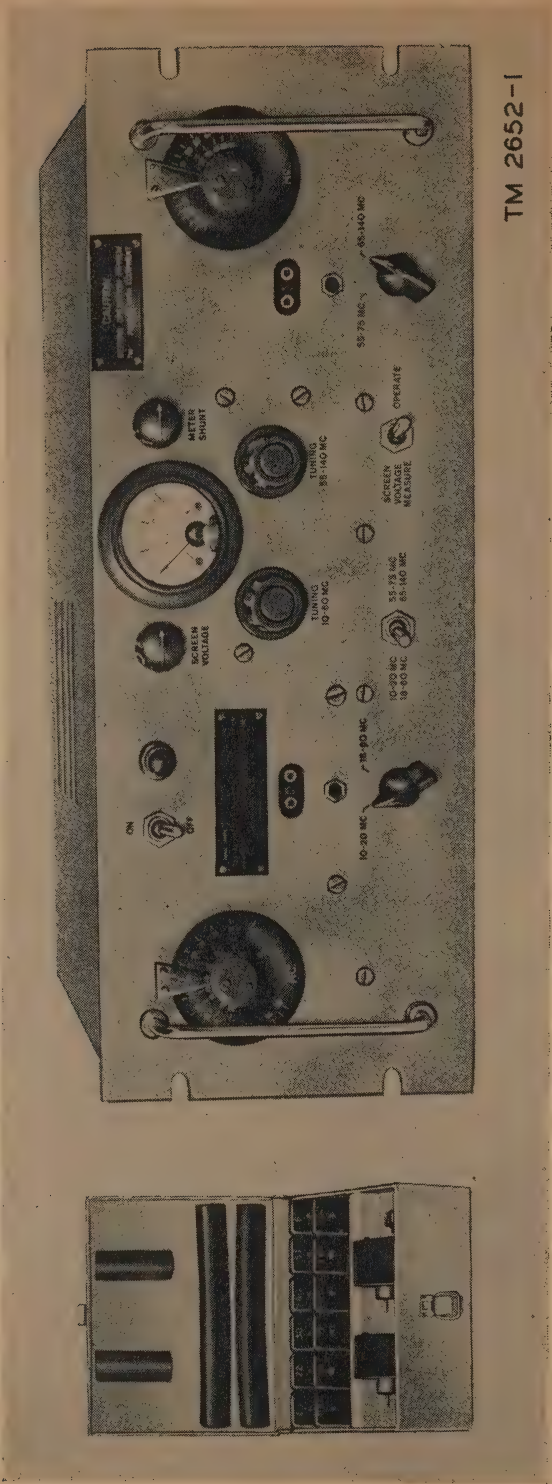

Figure 1. Crystal impedance meter TS-683/TSM.

CHAPTER 1
INTRODUCTION

Section I. GENERAL

1. Scope

a. This manual contains complete information on the operation and the organizational and field maintenance of the equipment as well as a discussion of the theory of Crystal Impedance Meter TS–683/TSM.

b. Appendix I contains a list of current references including supply manuals, technical manuals, and other available publications applicable to the equipment. Appendix II contains an identification table of parts for Crystal Impedance Meter TS–683/TSM.

2. Forms and Records

The following forms will be used for reporting unsatisfactory conditions of Army equipment:

a. DD Form 6, Report of Damaged or Improper Shipment, will be filled out and forwarded as prescribed in SR 745–45–5 (Army), Navy Shipping Guide, Article 1850–4 and AFR 71–4 (Air Force).

b. DA Form 468, Unsatisfactory Equipment Report, will be filled out and forwarded to the Office of the Chief Signal Officer, as prescribed in SR 700–45–5.

c. AF Form 54, Unsatisfactory Report, will be filled out and forwarded to Commanding General, Air Materiel Command, Wright-Patterson Air Force Base, Dayton, Ohio, as prescribed in SR 700–45–5 and AFR 65–26.

d. Use other forms and records as authorized.

Section II. DESCRIPTION AND DATA

3. Purpose and Use

Crystal Impedance Meter TS–683/TSM (fig. 1) is used to measure the equivalent electrical parameters (par. 24) of quartz crystals of the type used for communication purposes. The equipment is designed specifically to test quartz crystal units for conformance with Military Specification MIL–C–3098 (1). Provision is made to measure directly the effective series-resonant and antiresonant resistances of a piezoelectric quartz crystal (in its holder). The series capacitance C can be computed (par. 24*c*) from the static capacitance C_0 of the

crystal unit (which can be measured by any conventional low-frequency capacity measuring unit), the load capacitance C_1 of the circuit (the value of which is set in Adapter AR–1), and the series-resonant and antiresonant frequencies. The inductance L can be computed from C and the nominal frequency of the crystal unit. The performance index (PI) is determined from these electrical parameters of the crystal unit. The PI is a measure of the activity of the crystal unit. The greater the activity of a crystal unit, the more satisfactory it is for communication purposes. Crystal Impedance

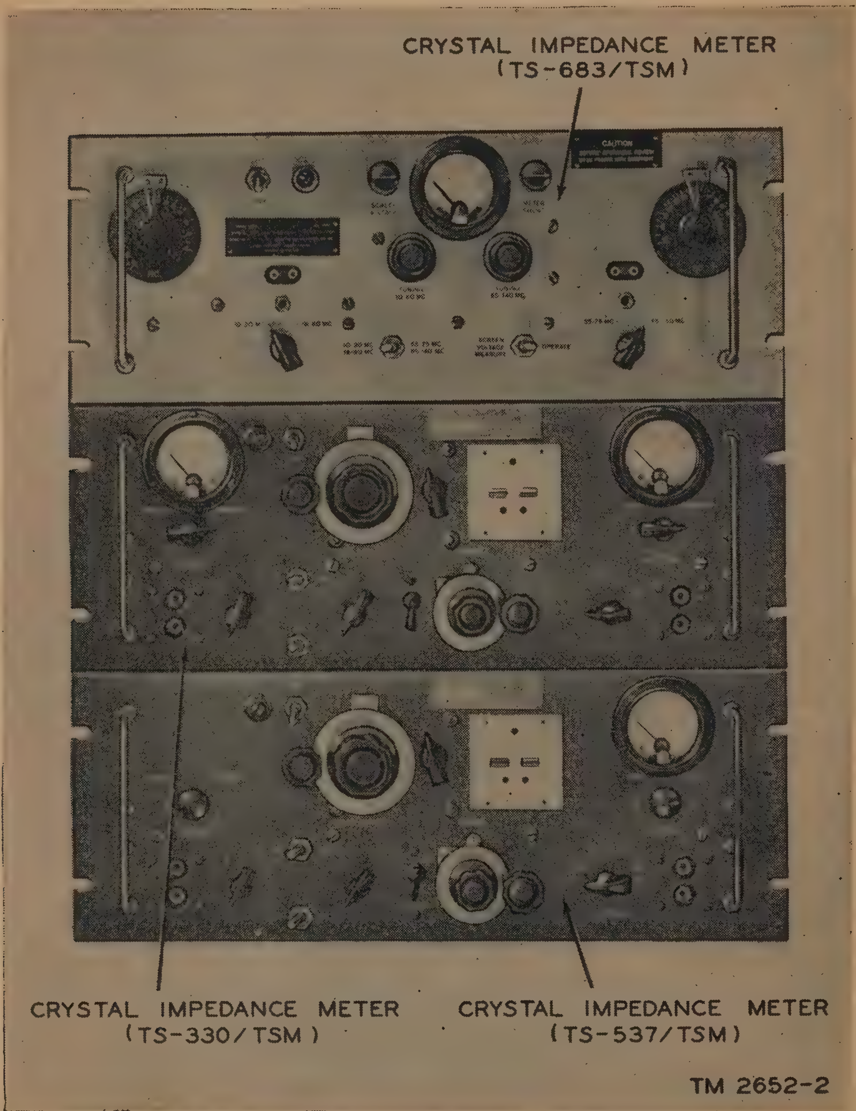

Figure 2. Crystal impedance meter, component of the TS–683/TSM with components of standard crystal test set AN/TSM–3.

Meter TS–683/TSM may be used in conjunction with Standard Crystal Test Set AN/TSM–3 (fig. 2). Crystal Impedance Meters TS–330/TSM, covered in TM 11–5051, and TS–537/TSM, covered in TM 11–5052, are a part of Standard Crystal Test Set AN/TSM–3.

4. General Description and Application

Crystal Impedance Meter TS–683/TSM (fig. 1) is used to determine the equivalent electrical parameters of crystal units (crystal oscillator plates mounted in crystal holders) in the frequency range of 10 to 140 mc (megacycles). The CI (crystal impedance) meter is inclosed in a gray, smooth-finished metal case designed for rack mounting. The overall dimensions of the unit are 19 inches long by 10½ inches wide by 7 inches high. The panel contains one meter, two crystal sockets, jacks, and various controls. The CI meter operates from a power source of 115 or 230 volts a-c (alternating current), 50 to 1,000 cps (cycles per second). A 5-foot, r-f (radio-frequency) output cable assembly with a plug attached, 12 calibrating resistors, a variable calibrating resistor, and an antiresonant adapter are furnished with the meter.

5. Technical Characteristics

The characteristics of Crystal Impedance Meter TS–683/TSM are as follows:

Frequency range	Four bands: 10 to 20 mc, 18 to 60 mc, 55 to 75 mc, 65 to 140 mc.
Resistance calibration	Twelve calibrating resistors with values of 10, 22, 30, 40, 51, 60, 68, 82, 91, 100, 120, and 150 ohms and a 100-ohm variable calibrating resistor are used.
Number of tubes	4.
Oscillator	V1 (type 5654).
Oscillator	V2 (type 5654) selected.
Rectifier	V3 (type 5Y3).
Voltage regulator	V4 (type OA2).
Required power source	115 v or 230 v ac, 50 to 1,000 cps, 30 w.

6. Packaging Data

When packaged for export shipment, Crystal Impedance Meter TS–683/TSM is placed in a moisture-vaporproof container (fig. 3). The packaged unit is 12 inches high by 34 inches long by 14½ inches wide; it has a volume of 3.8 cubic feet and weighs approximately 46 pounds.

7. Table of Components

Component	Required No.	Height (in.)	Depth (in.)	Length (in.)	Volume (cu. in.)	Unit weight (lb.)
Crystal impedance meter	1	7	10½	19	1, 395	19
R-f output cable	1	.405 dia	------	60	2. 6	. 62
Calibrating resistors	12	1	5/16	¾	. 235	. 19
Adapter AR–1, antiresonant adapter.	1	2	1⅝	1½	4. 9	. 19
Adapter VR–2, variable calibrating resistor.	1	1¾	2¼	1½	5. 9	. 2
Box for resistors and adapters	1	------	------	------	----------	------
Total	17	------	------	------	1, 408. 635	20. 2

Note. This list is for general information only. See appropriate supply publications for information pertaining to requisition of spare parts.

8. Description of Crystal Impedance Meter

a. Crystal Impedance Meter TS–683/TSM is a portable equipment designed to measure the equivalent circuit parameters of a piezoelectric crystal in the frequency range of 10.0 to 140.0 mc. The equipment consists of a power supply with a VR tube regulated voltage source, and two similar tuned-plate, tuned-grid variable frequency oscillators. One oscillator is used in coordination with crystals in the frequency range of 10 to 60 mc; the other oscillator is tuned to cover the 55- to 140-mc frequency range. A double-pole, double-throw switch selects the oscillator to cover the frequency range of the crystal unit to be tested. Each oscillator is subdivided into two bands. Selection of the desired band is controlled by a two-position switch. All circuits except the VOLTAGE CHANGE-OVER switch are operated by front panel controls. Voltage input selection is made by operating the switch at the rear portion of the chassis.

b. The CI meter is inclosed in a metal case designed for standard rack and panel mounting. The panel dimensions are 19 inches long by 7 inches high. The overall depth, including handles and cable connectors, is 10½ inches.

c. The meter dust cover, which constitutes the top and rear sides of the metal case, may be removed by unscrewing the nine binding-head screws on the sides and back of the unit.

9. Description of Minor Components

a. Twelve plastic-encased calibrating resistors, with pin connectors to match the spacing of the crystal sockets and having values of 10, 22, 30, 40, 51, 60, 68, 82, 91, 100, 120, and 150 ohms, are supplied

with Crystal Impedance Meter TS–683/TSM. The resistors are substituted for the crystal unit during the course of series-resonant and antiresonant resistance measurements.

b. A variable calibrating resistor, Adapter VR–2, is supplied as a convenient calibrating resistor for use below the 50-mc range. This adapter contains a 100-ohm composition rheostat. Two pin connectors, which match the spacing of the crystal socket, and a ground pin permit the adapter to be plugged into the crystal socket.

c. An antiresonant adapter (AR–1) is provided for insertion into either crystal socket on the meter panel. This adapter contains a similar socket to receive a crystal. When plugged into the adapter, a crystal is connected to the meter panel socket through an integral 32-$\mu\mu$f (micromicrofarad) load capacitor.

d. A small box is provided to hold the 12 calibrating resistors, the variable calibrating resistor, and the antiresonant adapter.

e. A 5-foot r-f output cable assembly is supplied with the meter.

10. Running Spares

The following running spares are supplied with each Crystal Impedance Meter TS–683/TSM:

2 tubes, type 5654.
1 tube, type 5Y3GT/G.
1 tube, type OA2.
6 fuses, 1 ampere, type 3AG.
1 lamp, pilot, 6 to 8 volts, .25 ampere.
1 cable, r-f pickup.

11. Additional Equipment Required

A radio receiver or a frequency meter of the proper range normally is used with Crystal Impedance Meter TS–683/TSM. This equipment is not supplied with the meter.

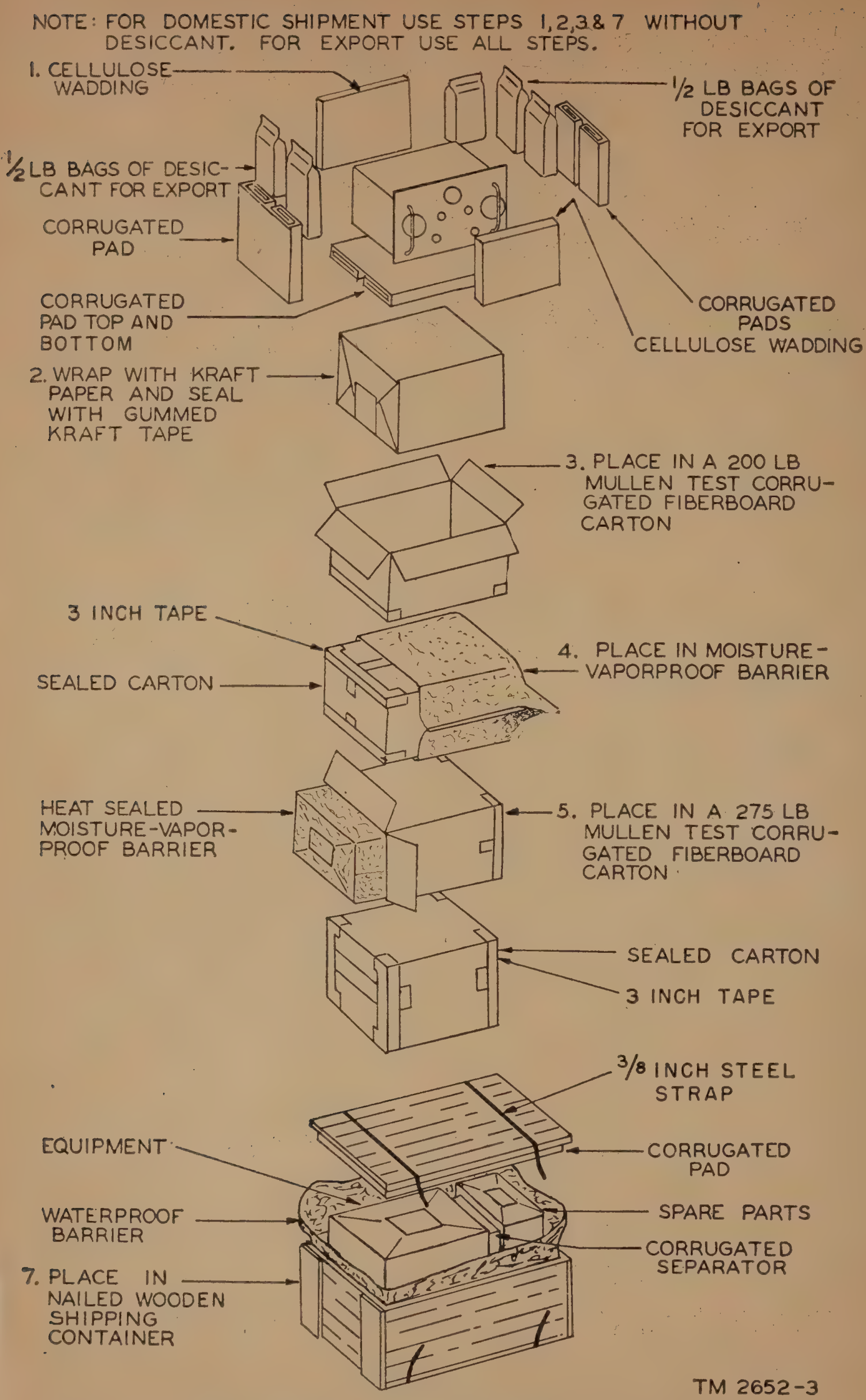

Figure 3. Crystal impedance meter TS–683/TSM, packaging diagram.

CHAPTER 2

OPERATING INSTRUCTIONS

Section I. SERVICE UPON RECEIPT OF EQUIPMENT

12. Uncrating, Unpacking, and Checking New Equipment

a. General. Equipment may be shipped in export packing cases or in domestic packing cases. When new equipment is received, select a location where the equipment may be unpacked without exposure to the elements and which is convenient to the permanent or semipermanent installation of the equipment. The instructions in *b* below apply to equipment shipped in export packing cases, and the instructions in *d* below apply to equipment shipped in domestic packing cases. Except for checking to make sure that all carrying cases are present and that the equipment is undamaged, no special unpacking and uncrating procedures are necessary for equipment shipped in carrying cases. Save the original packing cases and containers for both export and domestic shipments. They can be used again when the equipment is repacked for storage or shipment.

Caution: Be careful when uncrating, unpacking, and handling the equipment; it is damaged easily. If it becomes damaged or exposed, a complete overhaul may be required or the equipment may be rendered useless.

b. Step-by-step Instructions for Uncrating and Unpacking Export Shipment.

(1) Place the packing case as near the operating position as convenient.

(2) Cut and fold back the steep straps.

(3) Remove the nails with a nail puller. Lift off the top of the packing case.

(4) Remove the waterproof container or moistureproof barrier and the corrugated paper covering the equipment inside the case.

(5) Remove the equipment from the corrugated fiberboard carton and place it on a workbench or near its final location.

(6) Inspect the equipment for possible damage incurred during shipment.

(7) Check the contents of the packing case against the master packing slip.

c. Opening Cardboard Carton and Waterproof Barrier. Be careful not to injure the equipment when opening the waterproof paper barrier and removing the equipment from the cardboard carton.

d. Unpacking Domestic Packing Cases. The equipment may be received in domestic packing cases. The instructions in *b* above apply also to unpacking domestic shipments. Cut the metal bands. Open the cartons that protect the equipment; or, if heavy wrapping paper has been used, remove it carefully and take out the components. Check the contents of the packing case against the master packing slip.

Note. For used or reconditioned equipment, refer to paragraph 14.

13. Installation of Equipment

The following steps should be followed in the installation of the equipment:

a. Check the contents of the packing case against the master packing list.

b. Thoroughly inspect the exterior of the CI meter for possible damage in shipment.

c. Loosen the nine binding-head screws on the sides and back of the unit, and remove the metal dust cover. Also remove the bottom cover plate.

d. Make sure the vacuum tubes are not broken and that they are seated properly in their sockets. (Note that both oscillator tubes are located underneath the chassis.)

e. Inspect the wiring to make certain that the lugs are fastened securely to the leads and that leads are fastened securely to points of contact.

f. Inspect the subassembly parts such as the terminal strips to make certain that they are fastened securely in place.

g. Remove the cap from the fuseholder on the rear of the unit (fig. 7) and see that the fuse (1-ampere) has been installed.

h. Replace the dust cover and the bottom cover plate.

Caution: The chassis of the CI meter has been moistureproofed and fungiproofed. Do not remove any of the protective coating.

14. Service Upon Receipt of Used or Reconditioned Equipment

a. Follow the instructions in paragraph 12 for uncrating, unpacking, and checking the equipment.

b. Refer to paragraph 13 for installation procedures.

c. Check the used or reconditioned equipment for tags or other indications pertaining to changes in the wiring of the equipment. If any changes in the wiring have been made, note the change in this manual, preferably on the schematic diagram.

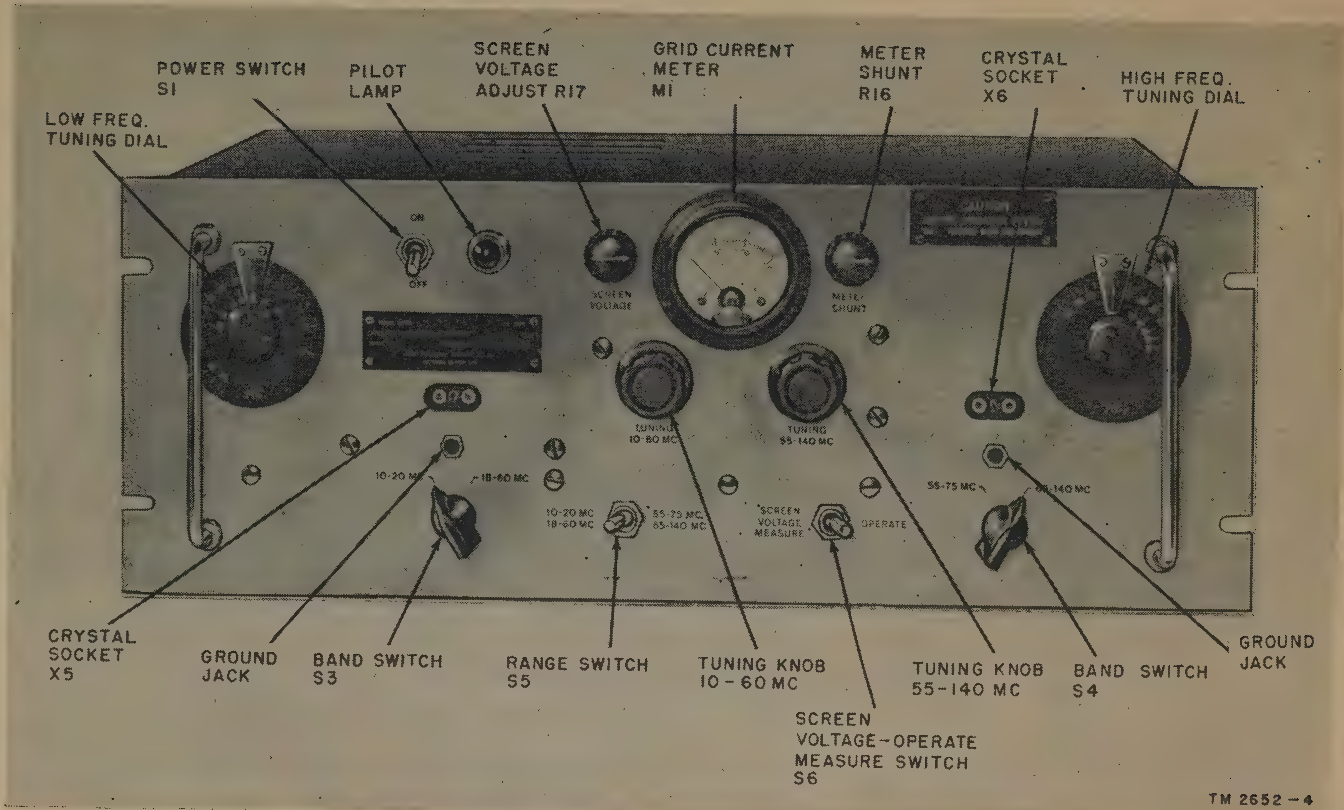

Figure 4. Crystal impedance meter TS-683/TSM, front panel view.

Section II. CONTROLS AND INSTRUMENTS

15. General

Haphazard operation or improper setting of the controls can cause damage to electronic equipment. For this reason, it is important to know the function of every control. The actual operation of the equipment is discussed in paragraphs 17 and 18.

Caution: It is of great importance that VOLTAGE CHANGE-OVER switch S2 (fig. 7) on the rear of the unit be set correctly and locked in the operating voltage position. SCREEN VOLTAGE control R17 should be set to its lowest value (extreme counterclockwise position) before power ON-OFF switch S1 is thrown to the ON position.

16. Table of Controls and Instruments

The following table lists the controls and instruments on the equipment and indicates their functions. Refer to figures 4 and 8 for illustrative identification of these controls and instruments.

Control	Function
ON-OFF switch S1	Switches power on and off when CI meter is connected to power source.
115 V or 230 V VOLTAGE CHANGE-OVER switch S2 (located on rear of chassis).	Connects power transformer primary windings for 115- or 230-volt operation.
10–20 MC—18–60 MC switch S3 (rotary band switch).	Selects frequency band of low-frequency oscillator.
55–75 MC—65–140 MC switch S4 (rotary band switch).	Selects frequency band of high-frequency oscillator.
10–20 MC 55–75 MC—18–60 MC 65–140 MC switch S5 (range switch).	Connects either high- or low-frequency oscillator into operating circuit.
SCREEN VOLTAGE MEASURE—OPERATE switch S6.	Connects meter M1 to read grid current in OPERATE position and to read screen voltage in SCREEN VOLTAGE MEASURE position.
Low-frequency tuning dial (10–60 MC).	Tunes low-frequency oscillator to desired frequency. Used in connection with switches S3 and S5.
High-frequency tuning dial (55–140 MC).	Tunes high-frequency oscillator to desired frequency. Used in connection with switches S4 and S5.
SCREEN VOLTAGE control (R17).	Varies screen voltage of oscillator tubes and adjusts drive level.
METER SHUNT control R16	Varies value of shunt resistor across grid current meter.
Grid current meter M1	D-c microammeter used to measure a convenient proportion of total rectified grid current. It also is used as a d-c voltmeter (with external multiplying resistor) to measure screen voltage.

Control	Function
Crystal sockets X5 and X6	Two-pin sockets with a center-to-center spacing of .486″ made to accept pins of .050″ in diameter.
Ground jacks J2 and J3	Provide convenient ground connections below crystal sockets.
Light indicator (I1) (pilot lamp)	Incandescent lamp, covered by lens, which lights when current is flowing through primary of transformer T1.
R-f output jack J1	A coaxial cable receptacle from which a small portion of the r-f output of the CI meter may be connected (via r-f cable assembly W5) to frequency measuring equipment.
Fuseholder E2	Holds 1-ampere fuse.

Section III. OPERATION UNDER USUAL CONDITIONS

17. Starting Procedure

Perform the starting procedure given below before using the operating procedure described in paragraph 18. If any abnormal condition is observed during the starting procedure, throw the ON-OFF switch to the OFF position, disconnect the power cable, and refer to the equipment performance checklist (par. 41).

Note. All initial adjustments on the TS–683/TSM are made during manufacture; field adjustments should not be necessary. The capacitor in Adapter AR–1 has been factory-adjusted to 32 $\mu\mu f$. This adjustment should not be altered.

a. Set the METER SHUNT control fully clockwise.

b. Set the SCREEN VOLTAGE control fully counterclockwise.

c. Determine whether the power source is 115 volts or 230 volts, and set VOLTAGE CHANGE-OVER switch S2 (located on back of chassis) to the proper value. The proper setting for either source voltage is marked clearly on the chassis.

d. Insert the power cord into the a-c outlet.

18. Operating Procedure

a. *Measurement of Series-Resonant Resistance.*

(1) Switch the ON-OFF switch to the ON position. Observe the pilot lamp to see that it is lighted. This indicates that current is flowing through the primary of transformer T1. Allow the CI meter to warm up for 15 minutes. Set range switch S5 (fig. 4) to the frequency range that includes the frequency of the crystal unit to be tested. If switch S5 is set to the low position, adjust rotary band switch S3 (fig. 4) to the specific range desired. If S5 has been set to the high position, use rotary band switch S4 to obtain the proper setting.

(2) Plug the crystal unit into the appropriate socket (crystal socket X5 for the low-frequency range or crystal socket X6 for the high-frequency range).

(3) Turn the SCREEN VOLTAGE control slightly in a clockwise direction. Do not advance the control knob too far; this may cause the microammeter needle to deflect violently off scale when crystal resonant frequency is reached.

(4) Rotate the low-frequency tuning dial or the high-frequency tuning dial (depending on the desired frequency range) to obtain maximum grid current meter readings, and adjust the SCREEN VOLTAGE control for a reading of 50 to 75 μa (microamperes).

(5) Select two calibrating resistors: one to give a slightly higher reading, and the other to give a slightly lower reading, than the value obtained from the crystal unit.

(6) From the two resistors selected, use the calibrating resistor that gives the meter reading closest to that of the crystal unit, and set the drive level in the following manner:

(*a*) Determine the correct drive level for the crystal unit under test according to information given in the specification covering the particular crystal unit.

(*b*) Express this drive level in terms of a voltage, E, across the calibrating resistor by means of the formula:

$$E=\sqrt{PR}$$

where:

P=drive level, in watts,

R=resistance of calibrating resistor, in ohms.

Example:

$P=4$ mw$=.004$ watts, and

$R=40$ ohms.

$$E=\sqrt{PR}=\sqrt{(.004)(40)}=\sqrt{.16}$$

(*c*) Measure the voltage, E, in one of three ways outlined below.

1. Wrap two or three turns of No. 16 copper wire around each pin of a calibrating resistor. Insert the free end of each wire into the crystal socket on the panel. Keep the wire as short as possible; this will leave the calibrating resistor pins exposed for measurements. Measure the voltage from each pin to ground; use Electronic Multimeter TS–505/U and its high-frequency probe. Obtain the voltage, E, by subtracting the smaller voltage reading from the larger reading.

2. To measure the voltage, *E*, in a large number of crystals, use Electronic Multimeter ME–56/TSM–3. Insert the probe of the meter into the crystal socket on the panel. Plug a calibrating resistor into the voltmeter probe and read the voltage drop, *E*, directly on the voltmeter dial.

3. A third method that may be used is to construct a crystal diode differential voltmeter (fig. 5). This unit is frequency sensitive. Calibrate the microammeter in volts, using the method described in *1* above, for each frequency at which it is used. This meter, if properly calibrated, can be used as a rapid and fairly accurate method of setting the voltage, *E*, across a calibrating resistor.

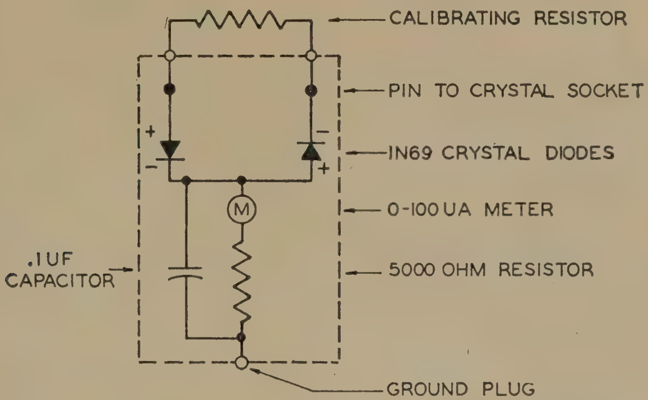

Figure 5. Differential voltmeter, schematic diagram.

(*d*) Vary the SCREEN VOLTAGE control and repeat the voltage measurements until the voltage drop is equal to that calculated in (*b*) above.

(*e*) The drive level now is adjusted properly for crystal units of the type and single-selected-frequency under test. This adjustment should remain constant throughout the remainder of the test. To reset this drive level for further measurements, note and record the screen voltage by holding the SCREEN VOLTAGE MEASURE—OPERATE switch in the SCREEN VOLTAGE MEASURE position and by reading the voltage on the lower scale of the meter. The correct drive level then may be obtained for crystal units of the same type and frequency by resetting the screen voltage to the recorded value. It is advisable, however, to check this setting occasionally by repeating the adjustment procedure given in (*c*) and (*d*) above.

(7) Remove the calibrating resistor and plug in the crystal unit. Rotate the tuning control to obtain maximum grid current meter reading. If the pointer goes off scale, adjust the METER SHUNT control for a convenient on-scale reading.
(8) Connect r-f cable assembly W5 between r-f output jack J1 and a radio receiver equipped with a bfo (beat-frequency oscillator); turn on the bfo. Obtain an approximate measurement of the crystal frequency by zero-beating the signal from the CI meter with the signal of the bfo of the receiver. Read the frequency from the receiver tuning dial or the calibration chart (ch. 4).
(9) Replace the crystal unit with the calibrating resistor that gives the closest grid current reading, preferably on the low side, to the crystal unit. Rotate the tuning control of the CI meter to obtain the signal frequency as in (8) above.
(10) Replace the crystal unit in its socket on the CI meter and, if necessary, readjust the *receiver tuning* for zero beat.
(11) Again substitute the calibrating resistor for the crystal unit. If the grid current meter reading is found to be greater than the reading for the crystal unit, select another calibrating resistor that gives the closest grid current reading, on the low side, to the crystal. Rotate the proper tuning control on the CI meter until zero beat is obtained again.
(12) Repeat the instructions in (10) and (11) above until the frequencies of the crystal unit and calibrating resistor are the same.
(13) Retain the crystal unit in the socket and adjust the METER SHUNT control for a convenient meter reading.
(14) Substitute a calibrating resistor in the crystal socket that will give a grid current reading just below, and another that will give a reading just above, that of the crystal unit.
(15) Note the values of the two calibrating resistors and the three grid current meter readings, and use the following method for calculating the effective series-resonant resistance, R, of the crystal unit.

$$R=R_1+\frac{(I_h-I_{xtal})(R_h-R_1)}{I_h-I_1}$$

where:

R_h =higher calibration resistance value,
R_1 =lower calibration resistance value,
I_h =higher grid current meter reading (using R_1),
I_1 =lower grid current meter reading (using R_h), and
I_{xtal} =crystal unit grid current meter reading.

Example:

$I_h = 128\ \mu a$
$I_{xtal} = 100\ \mu a$
$I_1 = 73\ \mu a$
$R_h = 22$ ohms
$R_1 = 10$ ohms

$$R = R_1 + \frac{(I_h - I_{xtal})(R_h - R_1)}{I_h - I_1}$$

$$= 10 + \frac{(128-100)(22-10)}{(128-73)}$$

$$= 10 + \frac{(28)(12)}{55} = 10 + \frac{336}{55}$$

$$= 16.11 \text{ ohms.}$$

(16) A slightly more accurate method of measuring the series-resonant resistance is to use four calibrating resistors and obtain two readings below the crystal unit grid current meter reading; then plot the points on rectangular graph paper and read the effective series resonance from the graph.

(17) To save time, and for the operator's convenience, the variable calibrating resistor may be substituted for the fixed resistors when crystals below 50 mc are tested. The CI meter is operated in the same manner as when the fixed calibrating resistors are used. Adjust the proper tuning dial and the variable resistor control knob until both frequency and grid current meter readings are the same as those obtained when using the crystal. When the variable resistor is used, the grid current is adjusted by turning the variable resistor control knob. The resistance of the crystal unit then may be determined by measuring the resistance across the pins of the variable calibrating resistor.

(18) An accurate measurement of the operating frequency now can be made by connecting r-f cable assembly W5 to an appropriate frequency measuring instrument such as the following: Frequency Meter Set SCR–211, Frequency Meter TS–174/U, or Frequency Calibrator-Meter Set AN/URM–18 (fig. 10). Selection of the frequency meter to be used depends on the frequency range and the accuracy desired (ch. 4).

b. Measurement of Antiresonant Resistance.

(1) Throw the ON-OFF switch to the ON position. Allow the CI meter to warm up for 15 minutes.

(2) Set range switch S5 to the proper frequency range. If switch S5 is set to the low position, adjust rotary band

switch S3 to the proper setting. If S5 is set to the high position, use rotary band switch S4 to obtain the proper setting.

(3) Insert Adapter AR–1 into the proper socket.

(4) Plug the crystal unit into the socket on the top of Adapter AR–1.

(5) Proceed as directed in *a*(3) through (17) above.

Note. For all antiresonant resistance measurements, Adapter AR–1 must be used in conjunction with the crystal unit.

c. Using Crystal Impedance Meter as Go—No Go Gage, Series-Resonant Operation. The *Go—No Go* method described below is to be used only as a rapid method for production testing of a quantity of crystal units. This method is to be used with the understanding that it has inherent inaccuracies; results obtained from using this method should be checked against accurate measurements obtained by the previously outlined methods to determine if the *Go—No Go* accuracy is sufficient for the intended use. When using this method, make sure that all crystal units being tested are of the same frequency, the only variation being in their values of effective resistance.

(1) Switch the ON-OFF switch to the ON position. Allow the CI meter to warm up for 15 minutes.

(2) Set range switch S5 (fig. 4) to the desired frequency range. If switch S5 is set to the low position, adjust rotary band switch S3 to the specific range desired. If S5 has been set to the high position, use rotary band switch S4 to obtain the proper setting.

(3) Adjust the crystal drive level according to information given in the specification covering the specific crystal unit under test. Where no definite drive level has been established, the crystal unit should be maintained at as low a level as possible. This is done by advancing the METER SHUNT control to its extreme clockwise position; then advance the SCREEN VOLTAGE control to a position which will give an adequate grid current meter reading (approximately half-scale).

(*a*) A more accurate method of setting drive level, when the correct drive is known, is to determine first the average effective resistance of a small quantity of production crystals of the same frequency. Use the series-resonant method described in *a* above.

(*b*) Substitute, in the crystal socket, a calibrating resistor which most closely approximates this average effective resistance value. Set the METER SHUNT control fully clockwise. Use the SCREEN VOLTAGE control to adjust the drive level obtained by the method in (*c*) below.

(c) Determine the correct drive level for the crystal unit, and use the formula below to calculate the voltage drop across the resistor that corresponds to this drive level.

$$E=\sqrt{PR}$$

where:

P=drive level, in watts,

R=average series-resonant crystal resistance, in ohms.

Note. For a method of measuring the voltage E, refer to a(6)(c) above.

(4) Insert the crystal unit into the proper socket.

(5) Adjust the proper tuning control for a maximum grid current meter reading. It may be necessary to adjust the METER SHUNT control for a convenient on-scale reading.

Caution: Do not disturb the setting of the SCREEN VOLTAGE control because this setting should remain fixed for the remainder of the test.

(6) Connect r-f cable assembly W5 from r-f output jack J1 to a radio receiver equipped with a bfo. Turn on the bfo. Obtain an approximate measurement of the crystal frequency by zero-beating the signal from the CI meter with that of the bfo of the receiver. Read the frequency from the receiver tuning dial or calibration chart (ch. 4).

(7) Substitute in the socket a calibrating resistor with a value that corresponds to the maximum resistance permissible for the frequency desired (as indicated in the applicable crystal unit specification).

(a) Adjust the tuning control of the CI meter so that the signal is at or near zero beat with the frequency as described in (6) above.

(b) Adjust the METER SHUNT control to obtain a convenient meter reading. This adjustment should remain fixed throughout the remainder of the test.

(8) Note the grid current value; this value is the passing activity level.

(9) Remove the resistor from the crystal socket.

(10) Proceed to test crystals by plugging one unit at a time into the crystal socket and noting the grid current values. Crystal units exhibiting a greater grid current meter reading than obtained as described in (7) (b) above, pass the activity requirements; those showing less, fail.

(11) This procedure must be repeated each time the crystal unit type and frequency are changed.

d. Procedure for Using Crystal Impedance Meter TS–683/TSM as Go—No Go Gage, Antiresonant Operation. This procedure is identical

with the instructions given for using the meter as a *Go—No Go* gage, series-resonant operation, with this change: For all antiresonant operations, the crystal unit must be used in conjunction with Adapter AR-1.

Section IV. OPERATION UNDER UNUSUAL CONDITIONS

19. General

The operation of Crystal Impedance Meter TS-683/TSM requires special care in regions where extreme cold, heat, humidity, moisture, or sand conditions prevail. In paragraphs 20 through 22 instructions are given on procedures for minimizing the effects of these unusual operating conditions.

20. Operation in Arctic Climates

Subzero temperatures and climatic conditions associated with cold weather affect the efficient operation of the equipment. Outlined below are general precautions for equipment operation under such conditions.

a. Handle the equipment carefully.

b. Keep the equipment warm and dry. Construct an insulated box for the equipment if it is not stored in a heated inclosure.

c. To operate, locate the equipment inside a heated inclosure where there is no danger of a cold draft striking the tubes when a door is opened. A sudden draft of cold air is often sufficient to shatter the glass envelope of a heated tube. If the inclosure is constructed so that this precaution is impossible, place a blanket or some barrier between the source of draft and the equipment.

d. When the equipment has been stored outdoors, or has been kept at low temperatures for an extended period of time, the following procedure is recommended before the equipment is transferred to warmer air:

(1) Gradually transfer the equipment from the cold to the warmer temperature by intermediate temperature steps. Allow 6 hours or more for this gradual transfer so that the equipment will have attained the temperature of the warmer room. Whenever possible, inclose the equipment in water-repellent material while transferring from cold to room temperatures. This latter precaution will reduce the possibility of condensation on the equipment.

(2) After equipment has reached the warmer temperature, use a lint-free cloth to remove any condensation that may have formed on the equipment.

Note. Special precautions necessary to prevent poor performance or total operational failure of the equipment in extremely low temperatures are explained fully in TB SIG 66 and TB SIG 219.

21. Operation in Tropical Climates

In climates of high humidity, such as the tropics, special attention should be given to the equipment to prevent corrosion. If the equipment is installed where moisture conditions are more acute than normal, some source of heat, such as electric bulbs, should be placed under the equipment. The CI meter should be inspected for traces of fungus, mold, mites, and metallic corrosion. All indications of fouling should be removed immediately. When not in use the equipment should be stored in a cool, reasonably dry place. For information on hydration, see TB SIG 149.

22. Operation in Desert Climates

When Crystal Impedance Meter TS–683/TSM is used under conditions of extreme heat or sand, such as desert regions, use the following precautions:

a. When conditions permit, house the equipment in a dustproof shelter. If the equipment must be operated outdoors, and a dustproof shelter is not available, expose the equipment as little as possible.

b. Do not tie power cables, signal cords, or any other wiring connections to any part of a tent; desert areas are subject to sudden wind squalls which may tear loose the connections or break the cables.

c. Keep the equipment as free from dust as possible. Make frequent preventive maintenance checks. Reduce lubrication intervals as required.

Note. Special precautions necessary to prevent equipment failure in areas subject to extremely high temperatures, low humidity, and excessive sand and dust are explained fully in TB SIG 75.

Section V. CRYSTAL PARAMETERS

23. Crystal Parameters, General

a. Piezoelectric Effect. When an electrical stress is applied to a cut quartz crystal in the direction of one of the major axes, a mechanical stress is produced at right angles to this axis. Conversely, a mechanical stress along a major axis will cause electrical charges to appear on the faces of the crystal perpendicular to the stress axis. The polarity of the electrical stress and the direction of the corresponding mechanical force are interrelated; a reversal in one causes a reversal in the other. This relationship between electrical stress and mechanical force is termed the piezoelectric effect and provides a means of relating mechanical vibrations to electrical circuits.

b. Resonance. An alternating voltage applied across a quartz crystal will cause the crystal to vibrate; if the frequency of the applied alternating voltage approximates a frequency at which mechanical resonance can exist in the crystal, the amplitude of the vibrations will be very large. Any crystal has several such resonant frequencies that

depend on the crystal dimensions, the type of oscillation involved, and the orientation of the plate cut from the natural crystal.

c. Properties of Piezoelectric Resonator. A good piezoelectric resonator possesses the following properties: a low-temperature coefficient of resonant frequency, a high piezoelectric activity (performance index), and a frequency spectrum containing only one resonant frequency in the vicinity of the desired oscillation. Temperature can alter the frequency of mechanical resonance through its effects on the density, the linear dimensions, and the moduli of elasticity of the crystal. Since some of the elastic constants are positive, and others are negative, the temperature coefficient of frequency may be either positive, negative, or zero, according to the mode of oscillation, the orientation of the crystal plate, and the shape of the plate. The electrical circuit associated with a vibrating crystal is shown in figure 6. The capacity, C_o, represents the electrostatic capacity between the crystal electrodes when the crystal is in place but not vibrating; the series combination of L, C, and R represents the equivalent mass compliance, and frictional loss of the vibrating crystal, respectively. Refer to TM 11–2540 for more detailed information on this subject.

24. Crystal Parameters, Measurement

a. Static Capacitance, C_0. The value of the static capacitance of the crystal unit, C_0, may be measured by any conventional capacitance measuring unit. If this measurement is made by using a Q-meter or an r-f bridge, be careful to select a frequency of operation somewhat lower than the crystal unit frequency. Figure 6 shows a diagram of the parameters of a piezoelectric crystal.

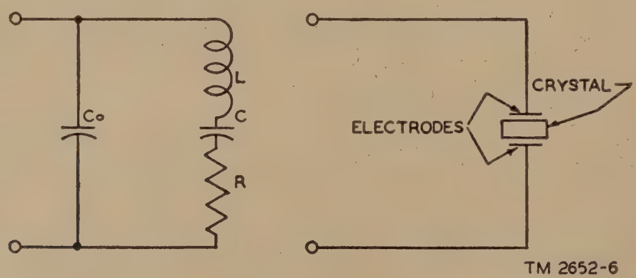

Figure 6. Equivalent electrical circuit of a piezoelectric crystal.

b. Series-Resonant and Antiresonant Resistances. The measurement of the effective resistance in ohms at series resonance is outlined in the operational procedure (par. 18*a*). The measurement of the effective resistance in ohms at antiresonance is outlined in the operational procedure (par. 18*b*).

c. Series Capacitance, C. Use the following equation to calculate the capacitance, C, of the series arm of the crystal unit:

$$C \text{ (in farads)} = \frac{2(C_0 + C_1)\Delta F}{F}$$

where:

ΔF=the difference between the antiresonant frequency and the series-resonant frequency $(F_a - F_s)$ in cps,

F=the nominal frequency of the crystal unit in cps,

C_0=the static capacitance of the crystal unit in farads, and

C_1=the load capacitance in farads.

d. Inductance, L. Use the following equation to calculate the inductance, L, in the series arm of the crystal:

$$L \text{ (in henries)} = \frac{1}{(2\pi f)^2 C}$$

where:

f=the nominal frequency of the crystal unit in cps, and

C=series capacitance, C, of the crystal unit in farads.

e. Voltage Across Crystal Unit. This voltage may be measured as in paragraph 18*a*(6)(*c*). Series resonance and antiresonance present two different cases as follows:

(1) *Series-resonant voltage.*

$$E = E_d = RI$$

where:

E=voltage across the crystal unit in volts,

E_d=difference between the two vacuum-tube voltmeter readings,

R=effective series-resonant resistance in ohms (par. 18*a*). and

I=r-f crystal current in amperes.

(2) *Antiresonant voltage.*

$$E = \frac{E_d}{2\pi F C_1 R_e} = \frac{I}{2\pi F C_1}$$

where:

E_d=difference between the two voltmeter readings,

F=nominal frequency of the crystal unit in cps,

C_1=load capacitance in farads,

R_e=effective antiresonant resistance in ohms (par. 18*b*), and

2π=6.28 (a constant).

f. Performance Index (PI). The *PI* of the crystal unit also may be calculated from the equation:

$$PI = \frac{X_e^2}{R_e} = \frac{1}{(2\pi F C_1)^2 R_e} = \frac{1}{(\omega C_1)^2 R_e}$$

where:

$$X_e = \frac{1}{2\pi F C_1}$$

$$\omega = 2\pi F$$

CHAPTER 3. ORGANIZATIONAL MAINTENANCE INSTRUCTIONS

Section I. TOOLS AND MATERIALS

25. Tools Required for Preventive Maintenance

The following common hand tools are necessary for preventive maintenance of Crystal Impedance Meter TS–683/TSM. These tools are contained in Tool Equipment TE–41:

Pliers, long-nosed, 5 inches to 6 inches.
Pliers, diagonal cutting, 5 inches to 6 inches.
Pliers, combination, 6 inches to 8 inches.
Screwdriver, 4-inch blade with ¼-inch tip.
Screwdriver, 2-inch blade with ⅛-inch tip.
Wrench, Allen, for No. 4 setscrew.
Iron, soldering, 60 to 100 watt, ¼-inch tip.
Puller, tube.

26. Materials Required for Preventive Maintenance

The following materials are necessary for preventive maintenance on Crystal Impedance Meter TS–683/TSM.

Solder, 40–60 grade, rosin core wire (part of Tool Equipment TE–41).
Orange stick.
Cheesecloth (part of Tool Equipment TE–41).
Carbon tetrachloride (part of Tool Equipment TE–41).
Paper, sand, flint No. 0000 and No. 00 (part of Tool Equipment TE–41).
Solvent, Dry Cleaning (SD).
Grease, instrument (GL) MIL–G–3278; ¼-ounce tube; QMC stock No. 14–G–610–900.
Oil, engine (OE–10).

Caution: Repeated contact of carbon tetrachloride with the skin or prolonged breathing of the fumes is dangerous. Make sure adequate ventilation is provided.

Section II. PREVENTIVE MAINTENANCE SERVICE

27. Definition of Preventive Maintenance

Preventive maintenance is work performed on equipment (usually when the equipment is not in use) to keep it in good working order so that breakdowns and needless interruptions in service will be kept to a minimum. Preventive maintenance differs from troubleshooting and repair since its object is to prevent certain troubles from occurring. See AR 750–5.

28. General Preventive Maintenance Techniques

a. Use No. 0000 sandpaper (Sig C stock No. 6Z7500–0000) to remove corrosion.

b. Use a clean, dry, lint-free cloth (Sig C stock No. 6Z1989) or a dry brush for cleaning.

(1) If necessary, except for electrical contacts, moisten the cloth or brush with solvent (SD) (Sig C stock No. 6G2361.1); then wipe the parts dry with a clean, lint-free cloth.

(2) Clean electrical contacts with a cloth moistened with carbon tetrachloride; then wipe them dry with a clean, lint-free cloth.

c. If available, dry compressed air may be used at a line pressure not exceeding 60 p. s. i. (pounds per square inch) to remove dust from

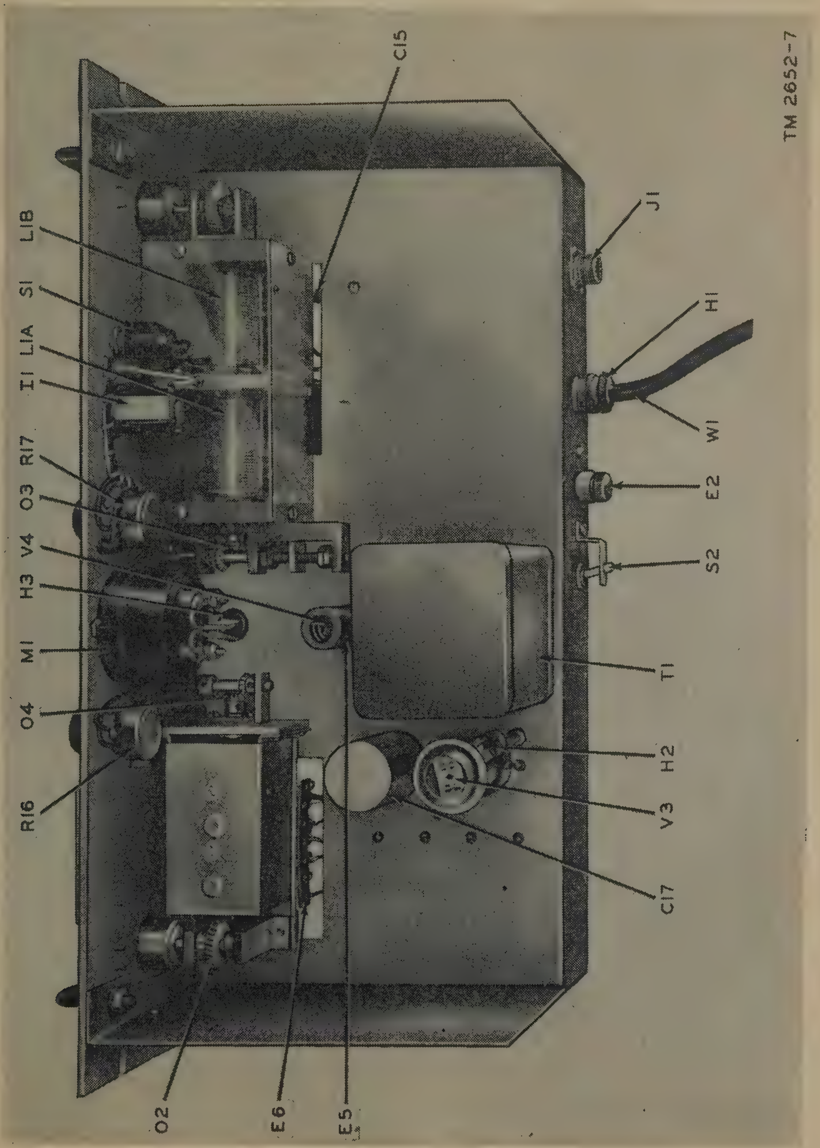

Figure 7. Panel and chassis assembly, top view, dust cover removed.

inaccessible places; be careful, however, or mechanical damage from the air blast may result.

d. For further information on preventive maintenance techniques, refer to TB SIG 178.

29. Performing Preventive Maintenance

The preventive maintenance operations in the table below should be performed by organizational personnel at the intervals indicated, unless these intervals are reduced by the local commander.

Caution: Screws, bolts, and nuts should not be tightened carelessly. Fittings tightened beyond the pressure for which they are designed will be damaged or broken. The *dress* or wire lead arrangement in parts of the CI meter must be maintained for proper operation. Be careful not to disarrange wires while cleaning.

Daily
Clean exterior of case.
Weekly
Caution: Disconnect all power before performing the following operations. Upon completion, reconnect power and check for satisfactory operation. 1. Clean interior of dust cover. 2. Inspect filter capacitor C17 for leakage of dielectric, for bulging, and for heating. 3. Inspect power transformer T1 for excessive heating. 4. Inspect fuse F1 and fuseholder for corrosion, cracks, and lack of tension sufficient to insure good contact.
Monthly
Note. Make visual inspection of the following; tighten and/or clean *if necessary*. 1. Tube and crystal sockets and pins for loose contacts, dirt, and corrosion. Check vacuum tubes; replace if necessary (figs. 7 and 8). 2. Filter capacitor C17 terminals for corrosion. 3. Resistors for blistering, discoloration, and other evidence of overheating. 4. Switches S3 and S4 for dirt, corrosion, and loose contacts. 5. Wires, cords, and cables for cracked, cut, and frayed insulation. 6. Terminal strips for cracks, dirt, and loose connections. 7. Potentiometers R16 and R17 for unsatisfactory electrical and mechanical operation. 8. Mountings, machine screws, and nuts for mechanical looseness. 9. All visible terminals and connections for loose connections and corrosion. 10. Moistureproofing and fungiproofing coatings for breaks. (Retouch with a brush, if necessary.) 11. Finish for scratches and bare spots. (Retouch, if necessary.) 12. Insulators for cracks and dirt. 13. Coil L1A, L1B, L2A, and L2B contacts for dirt and cutting. 14. Power transformer T1 for dirt, corrosion, and loose connections.

Section III. LUBRICATION

30. General

The following precautions should be observed when Crystal Impedance Meter TS–683/TSM is lubricated:

a. Do not use excessive amounts of oil or grease and do not allow connections to become greasy.

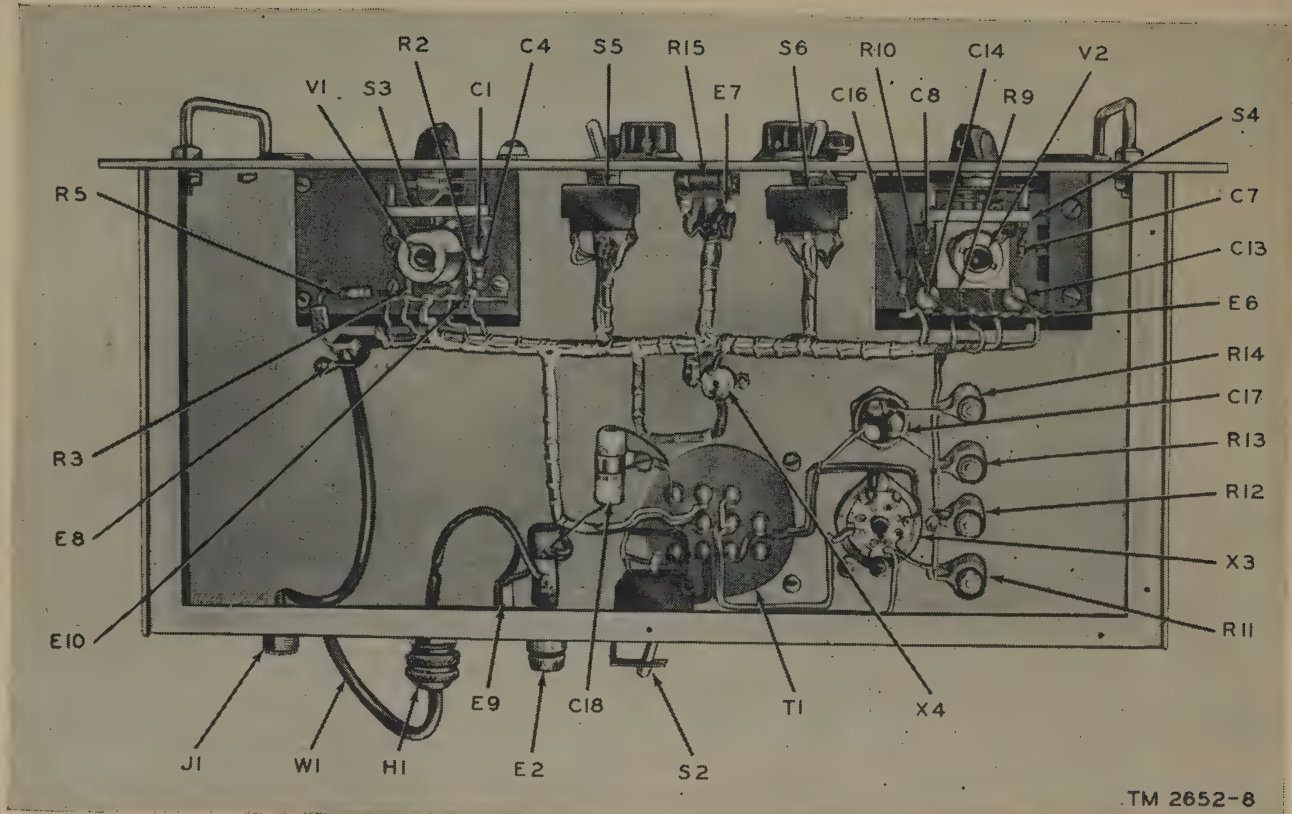

Figure 8. Panel and chassis assembly, bottom view, cover plate removed.

b. Be sure that lubricants and points to be lubricated are clean and free from sand, grit, or dirt. These abrasives are the chief cause of bearing wear and their presence often necessitates bearing replacements. Use solvent (SD) to clean all parts, except for electrical contacts. Before lubricating, clean all surfaces with a lint-free cloth dampened with solvent (SD). Keep solvent off surrounding parts.

31. Lubrication Instructions

Lubrication points are illustrated in figure 9.

a. Lubrication is performed during manufacture, and with normal care lubrication ordinarily is not required during the life of the equipment. If equipment is overhauled completely, lubricate it in accordance with information in figure 9 and paragraph 32.

b. Gasoline will not be used as a cleaning fluid for any purpose. When the unit is overhauled or repairs are made, clean the parts, except for electrical contacts, with solvent (SD).

c. Use carbon tetrachloride as a cleaning fluid only in the following cases: on electrical equipment where inflammable solvent cannot be used because of fire hazard, and for cleaning electrical contacts including relay contacts, plugs, commutators, etc.

32. Parts Lubricated by Manufacturer

The following chart lists the parts of the equipment which have been lubricated by the manufacturer prior to delivery of the equipment:

Parts lubricated	Lubricant
Teeth of all gears, both oscillator units	Grease, instrument (GL).
Bearings of both tuning knob and indicating dial shafts.	Oil, engine (OE–10).
Two end bearings of low-frequency (L1A and L1B) tuning indicator shaft.	Oil, engine (OE–10).
Threaded portion of low-frequency tuning shaft	Oil, engine (OE–10).

33. Parts Not Requiring Subsequent Lubrication

Part lubricated	Reason subsequent lubrication is not required
Low-frequency tuning inductor L1A and L1B end collector rings.	Under ordinary service conditions factory lubrication should last for life of unit.
Low-frequency tuning inductor L1A and L1B contact wheels and shaft.	Under ordinary service conditions factory lubrication should last for life of unit.
High-frequency tuning inductor L2A and L2B sliding contacts.	Under ordinary service conditions factory lubrication should last for life of unit.

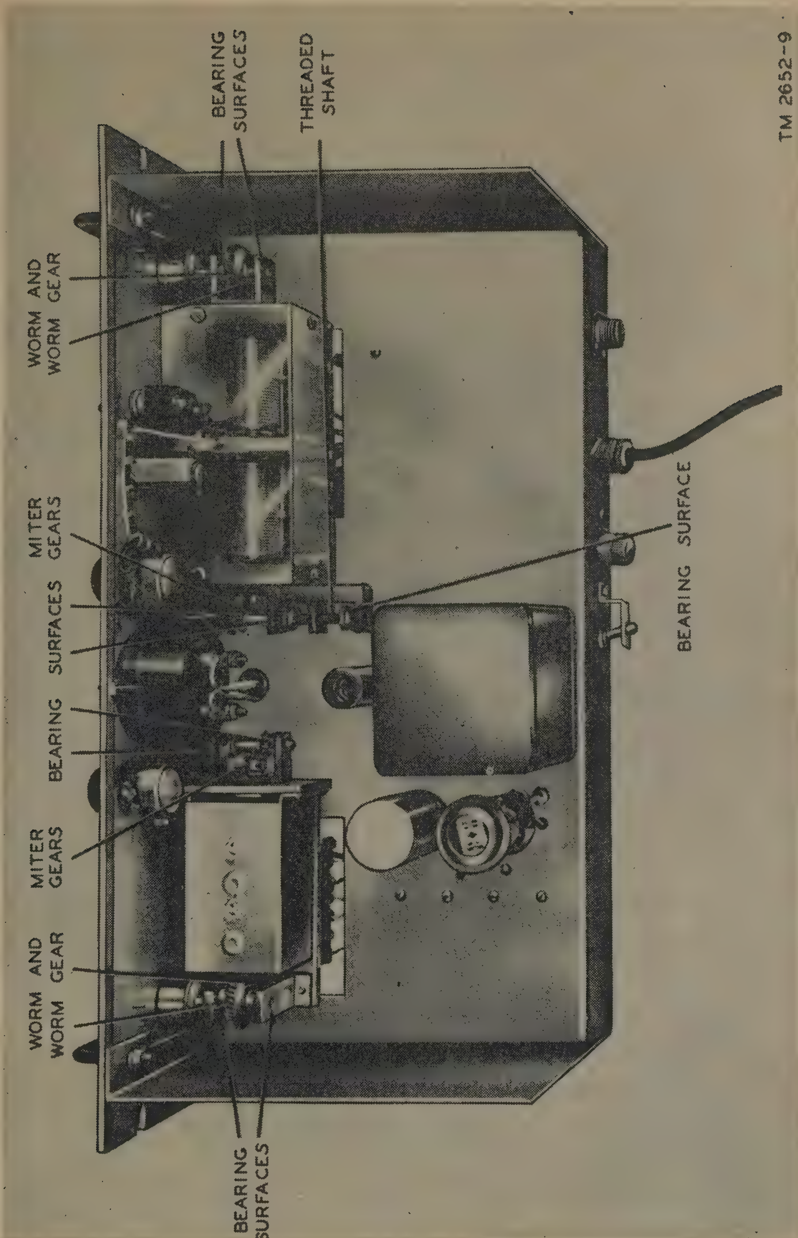

Figure 9. Crystal impedance meter TS-683/TSM, lubrication points.

34. Lubrication Under Unusual Conditions

a. Arctic Regions. Lubricants that are satisfactory at moderate temperatures stiffen and solidify at subzero temperatures; as a result, moving parts bind or become inoperative. Refer to TB SIG 66 and TB SIG 219 which provide information on lubricants to be used on various types of equipment at low temperatures. When preparing equipment for low-temperature operation, thoroughly remove lubricants used for moderate temperatures. Even small amounts of such lubricants, if allowed to remain, may impair the operation of moving parts. Be sure to use the lubricant specified for low-temperature operation.

b. Tropical Regions. High temperatures and moisture due to rain or condensation may cause lubricants which are normally satisfactory to flow from moving parts and other surfaces. These bearing surfaces will wear excessively, and hinges, fasteners, and other parts will be damaged or destroyed by rust and corrosion. Inspect the equipment daily and lubricate it as required to insure efficient operation; use lubricants that are suitable for high temperatures.

c. Desert Regions. Dust and sand infiltrating into the equipment cause grit in the lubricants and will seriously impair and damage the moving parts of the set. Hot dry temperatures cause the lubricants to flow from the moving parts, and conditions similar to those described in *b* above will result. Use lubricants that are suitable for high temperatures. Inspect and clean the equipment daily. Take the precautions prescribed in paragraph 22.

Section IV. WEATHERPROOFING

35. General

Signal Corps equipment, when operated under severe climatic conditions such as prevail in tropical, arctic, and desert regions, requires special treatment and maintenance. Fungus growth, insects, dust, corrosion, salt spray, excessive moisture, and extreme temperatures are harmful to most materials.

36. Treatment and Precautions

a. Tropical Maintenance. A special moistureproofing and fungiproofing treatment has been devised, which, if properly applied, provides a reasonable degree of protection. This treatment is explained fully in TB SIG 13 and TB SIG 72.

b. Winter Maintenance. Special precautions necessary to prevent poor performance or total operational failure of equipment in extremely low temperatures are explained fully in TB SIG 66 and TB SIG 219.

c. Desert Maintenance. Special precautions necessary to prevent equipment failure in areas subject to extremely high temperatures,

low humidity, and excessive sand and dust are explained fully in TB SIG 75.

d. Lubrication. The effects of extreme cold and heat on materials and lubricants are explained in TB SIG 69. Observe all precautions given in TB SIG 69 and pay strict attention to all lubrication orders when operating equipment under conditions of extreme cold or heat. Refer to paragraphs 30 through 34 for detailed instructions.

37. Rustproofing and Painting

a. When the finish on the case has been scarred or damaged badly, rust and corrosion can be prevented by touching up bared surfaces. Use No. 00 and No. 0000 sandpaper to clean the surface down to the bare metal; obtain a bright smooth finish.

Caution: Do not use steel wool. Minute particles frequently enter the case and cause harmful internal shorting or grounding of circuits.

b. When a touchup job is necessary, apply paint with a small brush. Remove rust from the case by cleaning corroded metal with solvent (SD). In severe cases, it may be necessary to use solvent (SD) to soften the rust and to use sandpaper to complete the preparation for painting. Paint used will be authorized and consistent with existing regulations.

Section V. TROUBLESHOOTING AT ORGANIZATIONAL MAINTENANCE LEVEL

38. General

The troubleshooting and repair work that can be performed at the organizational maintenance level (operators and repairmen) are necessarily limited in scope by the tools, test equipment, and replaceable parts issued, and by the existing tactical situation. Accordingly, troubleshooting is based on the performance of the equipment and the use of the senses in determining such troubles as burned-out tubes and cracked insulators.

39. Visual Inspection

a. Failure of this equipment to operate properly usually is caused by one or more of the following faults:

(1) Worn, broken, or disconnected cord or plug.
(2) Burned-out fuse.
(3) VOLTAGE CHANGE-OVER switch in the wrong position.
(4) Defective tubes.
(5) Burned insulation and resistors.
(6) Open or shorted capacitors.
(7) Loose or missing screws, especially those which fasten grounding lugs in place.
(8) Wires broken because of excessive vibration.

b. When failure is encountered and the cause is not immediately apparent, check as many of the above items as is practicable before starting a detailed examination of the component parts of the system. If possible, obtain information from the operator of the equipment regarding performance at the time trouble occurred.

40. Troubleshooting by Using Equipment Performance Checklist

a. General. The equipment performance checklist (par. 41) is to be followed in numerical sequence. It lists the items to be checked, the normal indication of effect to be expected, and the corrective measures to be taken.

b. Action or Condition. This column indicates what is to be done to the control or part mentioned in the item column.

c. Normal Indications. The normal indications listed include the visible signs that the operator should perceive when checking the items. If indications are not normal, the operator should apply the recommended corrective measures.

d. Corrective Measures. The corrective measures listed are those the operator can make without turning in the equipment for repairs. Reference to chapter 6 indicates that the trouble cannot be corrected at the organizational maintenance level, and that troubleshooting by an experienced repairman is necessary.

41. Equipment Performance Checklist

	Item No.	Item	Action or condition	Normal indications	Corrective measures
PREPARATORY	1	Line cord.	Plug into socket of a-c power source.		
	2	VOLTAGE CHANGE-OVER switch S2.	Place in proper position for power supply voltage.		
	3	SCREEN VOLTAGE control R17.	Set to full counterclockwise position.		
	4	METER SHUNT control R16.	Set to full clockwise position.		
	5	R-f output cable assembly W5.	Connect from jack J1 on rear of chassis to frequency measuring equipments.		
START	6	ON-OFF switch S1	Turn to ON position.	Panel lamp lights.	Check plug and line cord. Check fuse F1. Check panel lamp. Check voltage source. Check transformer T1.
EQUIPMENT	7	Range switch S5	Set to low-frequency range		
	8	Rotary band switch S3.	Set to 10–20 MC position.		
	9	100-ohm calibrating resistor	Plug into crystal socket below nameplate.	Meter should read 30 μa or higher between 10 to 20 mc.	Refer to chapter 6.
	10	Rotary band switch S3.	Set to 18–60 MC position.		
	11	100-oh m calibrating resistor	Plug into crystal socket below nameplate.	Meter should read 30 μa or higher between 18 to 60 mc.	Refer to chapter 6.

41. Equipment Performance Checklist—Continued

	Item No.	Item	Action or condition	Normal indications	Corrective measures
PERFORMANCE	12	Range switch S3.	Set to high-frequency range.		
	13	Rotary band switch S4.	Set to 55–75 MC position.		
	14	100-ohm calibrating resistor.	Plug into crystal socket below nameplate.	Meter should read 30 μa or higher between 55 to 75 mc.	Refer to chapter 6.
	15	Rotary band switch S4.	Set to 65–140 MC position.		
	16	100-ohm calibrating resistor.	Plug into crystal socket below nameplate.	Meter should read 30 μa or higher between 65 to 110 mc.	Refer to chapter 6.
	17	SCREEN VOLTAGE MEASURE—OPERATE switch S6.	Hold in SCREEN VOLTAGE MEASURE position. Vary SCREEN VOLTAGE control.	Meter will read from 0 to 150 volts as control is varied	Refer to chapter 6.
STOP	18	ON-OFF switch S1.	Turn to OFF position.	Panel lamp goes out. Equipment goes off.	ON-OFF switch defective. Refer to chapter 6.

CHAPTER 4
AUXILIARY EQUIPMENT

Section I. FREQUENCY MEASURING EQUIPMENT

42. Standard Frequency Test Rack

The CI meter is coupled to a standard frequency test rack to measure the exact frequency of crystal units. The standard frequency test rack (Frequency Calibrator-Meter Set AN/URM–18) (fig. 10) consists of the items listed below:

Frequency Calibrator FR–46/URM–18
Multivibrator Power Supply O–122/URM–18
Frequency Meter FR–43/URM–18
Frequency Meter FR–44/URM–18
Frequency Meter FR–45/URM–18
AF Signal Generator SG–42/URM–18
Oscilloscope OS–16/URM–18
Control Panel SB–105/URM–18
Magnetic Loudspeaker LS–205/U
Rack MT–746/U
Rack MT–747/U

Note. The crystal frequency measuring procedure in paragraph 45 is a sample procedure. For a complete discussion on the use of the frequency calibrator meter set, refer to the applicable publication. Only those components used in the frequency measuring procedure in paragraph 45 will be discussed.

43. Alternate Equipment

Alternate frequency measuring equipment as described in the following subparagraphs may be used in place of the equipment listed in paragraph 42.

a. A calibrated radio receiver may be used. The degree of accuracy will be low, however, because of the frequency variation that commonly is found in such radio circuits.

b. Frequency Meter Set SCR–211, covering a calibrated range from 125 kc (kilocycle) to 20 mc, may be used in an emergency to supply the frequency standard in place of the multivibrator unit or interpolation oscillator (Signal Generator SG–42/URM–18). It may be used directly for measurement of crystals with frequencies between 10 and 20 mc. Its main function, however, is to tune and calibrate radio receivers in a net to a given frequency. Frequency Meter TS–174/U covering a calibrated range from 20 to 280 mc may be used directly for measurement of crystals with frequencies between 20 and 140 mc.

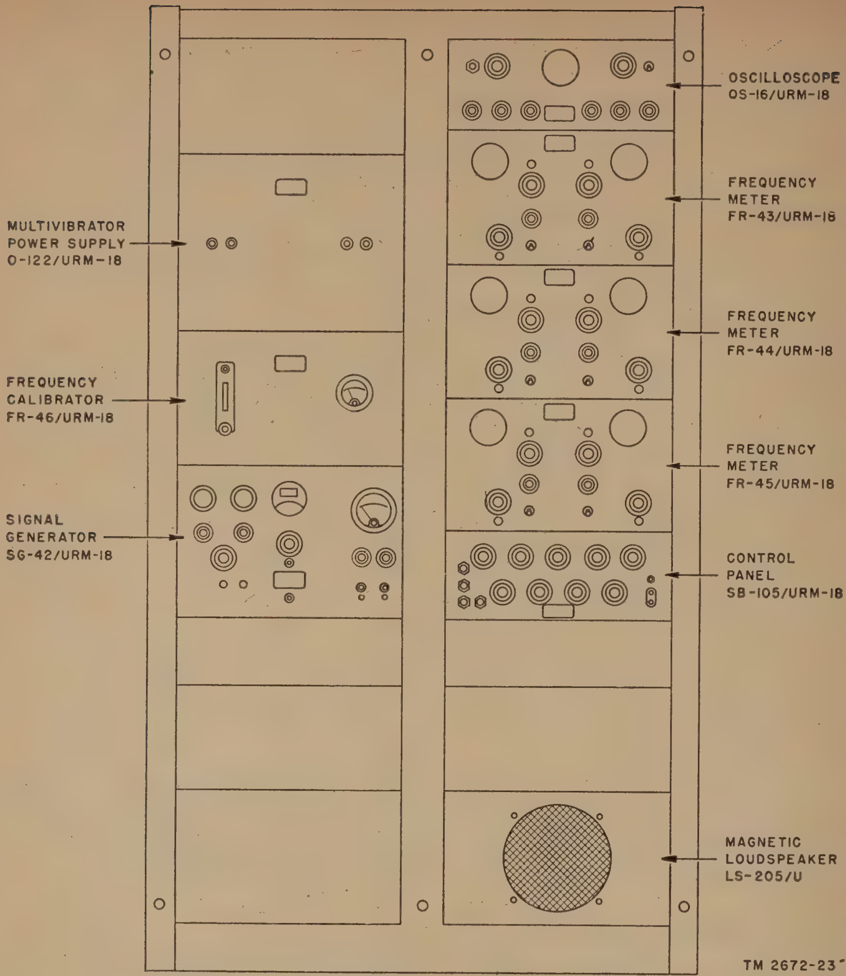

Figure 10. Frequency calibrator-meter set AN/URM-18

Section II. PROCEDURES FOR MEASURING FREQUENCIES ACCURATELY

44. General Instructions for Using Standard Frequency Test Rack

When using the AN/URM–18 as described in paragraph 42, the frequencies of crystal units in the range of 10–100 mc may be measured accurately. Apply power to all units in the test setup; allow the equipment to warm up for at least 15 minutes. Proceed as instructed in paragraph 45.

45. Crystal Frequency Measurements

a. Preliminary Procedures.

(1) Crystal frequencies are measured under series-resonant or antiresonant conditions. The measuring procedures are

the same, except that the CI meter adjustments are different. A general measurement of the frequency of a crystal is given in (2) and (3) below.

(2) Insert the crystal in the appropriate frequency crystal jack on the panel of the CI meter and couple the output (r-f) cable to the f_x jack on the front or the rear of Control Panel SB–105/URM–18 (fig. 10). Switches, coaxial jacks, patch cords, or any other method of making the interunit connections may be used; this depends on the permanency of the installation, available material, etc. Long connections, whether cable or open wire, should be avoided because of possible losses, pickup, radiation, etc. Adjust the CI meter for series-resonant (par. 18*a*) or antiresonant (par. 18*b*) operation. Move the f_x switch on the control panel to the H position (for Frequency Meter FR–45/URM–18). Move the DETECTOR-INTERPOLATOR switch to the TEL or SPKR position (depending on which item is being used for aural detection) on the DETECTOR side of the switch.

(3) Move the POWER—OFF switch on Frequency Meter FR–45/URM–18 to the POWER position. Rotate the detector RANGE switch to select the desired frequency range. Adjust the f_x volume control, the detector tuning control, and the REGENERATION control to obtain the required signal at its fundamental frequency.

b. Use of Frequency Meter.

(1) The effective operation of a regenerative detector requires a certain amount of practice. The beginning of oscillations usually occurs when the REGENERATION control has been advanced about one-quarter to one-half from the minimum position. For any given frequency setting, the most sensitive condition for receiving continuous wave signals, is just *after* oscillations have started. The most sensitive condition for modulated signals is just *below* the point at which oscillations start. It is therefore extremely important that the REGENERATION control be carefully adjusted. If the control is advanced too far, the detector may be blocked, causing a squeal to be heard in the output.

Caution: Do not apply too strong a signal to the detector, so as to cause overloading. Sensitivity is best at fairly low signal strength. When trying to obtain beats between two signals, adjust them individually to about the same level. If continuous wave signals are being received, too strong a signal may lock the detector into synchronization over an appreciable range on the frequency dial.

(2) If difficulty is encountered in picking up a signal whose frequency is only approximately known, introduce a standard harmonic frequency signal by moving the STANDARD FREQUENCY HARMONICS switch on the control panel to the 100-kc or 10-kc position, and advancing the corresponding volume control. Adjust the detector to obtain a sensitive oscillating condition on any of the standard frequency signals. After the detector has been adjusted, move the STANDARD FREQUENCY HARMONICS switch to the OFF position, and proceed to search the resultant small range for the desired signal. Use a preadjusted detector for this purpose.

(3) If the frequency to be measured is higher than 20 mc, it may be difficult to obtain the beat frequency difference directly against the standard; the harmonics of the standard being used are so close together that considerable care is necessary to identify the harmonic used in the measurement. Coincidental with their closeness, such high order harmonics become weaker and weaker as the frequency is raised until a point is reached where satisfactory beats between the standard frequency harmonic and the unknown frequency can no longer be obtained.

(4) When attempting to measure a high frequency in a range where a satisfactory beat cannot be obtained, use the frequency meter component of the FR–45/URM–18. Set the frequency meter (the FR–45/URN–18, or the meter covering the next lower range, the FR–44/URM–18) to a known fraction of the frequency being measured. This can be accomplished because the approximate value frequency measurement is known immediately from the calibration of the detector unit. Measure the fundamental frequency of the frequency meter being used, and multiply the result by the number of harmonics to obtain the value of the unknown frequency. When performing the above operations, the M-H position on the control panel FREQUENCY METER switch can be used to great advantage.

c. Deriving Audio Beat Difference Between Transferred and Standard Frequencies. After the frequency to be measured has been picked up and identified in the detector unit of the FR–45/URN–18 (detector usually in oscillating condition), introduce the standard frequency harmonics into the detector as given below.

(1) Move the STANDARD FREQUENCY HARMONICS switch on the control panel to the 10-kc position and adjust the corresponding volume control.

(2) Retard the REGENERATION control slightly, until oscillation stops, in order to reduce the amount of regeneration

in the detector. A single clear tone should now be heard from the telephones or speaker.

(3) Vary the adjustments of the f_x and the 10-kc volume control to obtain the best beat frequency signal. If a high frequency is being measured, try the 100/10-kc position on the selector switch, adjusting the 100- and 10-kc volume controls to obtain the best results.

(4) Critical regeneration is not needed when using the detector in the non-oscillating condition (if the signal levels are high enough). The r-f signal levels can be adjusted to higher values, resulting in greater beat frequency output. Do not, however, adjust the signal level for more than a comfortable telephone signal.

(5) When weak signals are received, advance the REGENERATION control on the control panel to the point where oscillation almost begins. In this case, the regeneration and detector controls must be tuned carefully to obtain the best beat frequency output.

d. Determining Sign of Beat Frequency Difference.

(1) If the sign of the beat frequency difference is not known (if the sign is above or below the standard beat frequency harmonic), the location of the unknown frequency relative to the standard harmonic frequency can be determined from the detector tuning adjustment. Using the detector in the oscillating condition, obtain the zero beat against the frequency being measured.

(2) Move the f_x switch to the OFF position and set the STANDARD FREQUENCY HARMONICS selector switch on the 10-kc position. A beat note will result. *Carefully advance* (clockwise) the detector tuning control; if the beat note *rises*, the unknown frequency is *higher* than the standard frequency, establishing the sign of the beat frequency difference as *plus*. If the beat tone *falls*, the unknown frequency is *lower* than the standard frequency and the sign of the beat frequency difference is *minus*.

e. Determining Value of Beat Frequency Difference.

(1) The beat frequency difference is applied automatically to the input terminals on Signal Generator SG–42/URM–18 (interpolation oscillator). Move the DETECTOR-INTERPOLATOR switch to the TEL or SPKR position on the interpolator side of the switch and listen to the match between the interpolation oscillator and the beat frequency. Adjust the INPUT (beat frequency) and OUTPUT (oscillator) volume controls on the interpolation oscillator until equal deflection is obtained on the output meter at half-scale.

(2) If the sign of the beat frequency difference is *plus*, move the DIRECT—REVERSE (scale selector) switch on the interpolation oscillator to the DIRECT position. Adjust the frequency of the interpolation oscillator to match the beat frequency. As the match is approached, the output meter needle will swing from nearly zero to nearly full scale. Adjust the frequency of the interpolation oscillator until the meter needle stands still, or moves very slowly. Slow oscillation of the meter needle is accompanied by a slow waxing and waning of the intensity of the note heard in the speaker or phones (connected directly to the interpolation oscillator). The direct scale on the interpolation oscillator now indicates the value of the beat frequency in cycles per second.

(3) To obtain the final value of the frequency being measured, *add* the value of the beat frequency difference to the value of the standard frequency. If the sign of the beat frequency difference is minus, move the scale selector switch to REVERSE, and proceed as instructed in (2) above to match the beat frequency. The REVERSE scale reading of the interpolation oscillator now gives the value of frequency difference to be added to the *next lower standard frequency harmonic* to obtain the final value of the frequency being measured.

46. References

For detailed information on frequency test equipment, refer to TM 11–2540, TM 11–2530, and TM 11–2606. TM 11–2540 covers quartz crystals—theory, fabrication, and performance measurements; TM 11–2530 covers Frequency Standard TS–308/U; TM 11–2606 covers Test Set AN/FSM–3, Tool Equipment TK–40/FSM–3, and Maintenance Kit MK–40/FSM–3.

CHAPTER 5
THEORY

Section I. OVERALL THEORY OF OPERATION

47. General

Crystal Impedance Meter TS–683/TSM measures the equivalent circuit parameters of a piezoelectric crystal in the frequency range of 10.0 to 140.0 mc. The CI meter consists of two tuned-plate, tuned-grid, variable-frequency oscillator circuit and a conventional power supply (fig. 14). Each circuit covers one of the specified frequency ranges, with switches to permit the use of either circuit (figs. 11, 12, and 13). The crystal under test, or any one of 12 fixed calibrating resistors in the range from 10 to 150 ohms, can be made part of a feedback network. The magnitude of the oscillations is indicated by the microampere scale on the panel meter.

48. Functioning of Crystal Impedance Meter TS–683/TSM

a. General.

(1) The crystal impedance meter is essentially a tuned-grid oscillator circuit (figs. 11, 12, and 13) in which the crystal unit to be tested is placed in the feedback path. The crystal unit thus controls the oscillation frequency of the circuit and the amplitude of oscillation. The effective resistance of the crystal unit is measured by application of the following principle of substitution: In any system, if an element of the system is removed and a substitute element is inserted so that the original set of boundary conditions is satisfied and no new ones are added, the substitute element is equivalent operationally to the original element. Thus, if the boundary conditions (oscillation frequency and amplitude of oscillation) are measured at some point in the circuit, a network of resistance and reactance is substituted for the crystal unit without changing the boundary conditions; then the network represents the crystal unit at that particular frequency and amplitude of oscillation. The crystal unit may be operated at either its series-resonant frequency or at antiresonant frequency.

(2) At series resonance, the equivalent electrical circuit (fig. 6) of the crystal unit is purely resistive. At antiresonance, the equivalent electrical circuit of crystal unit is inductive. Thus, if the crystal unit is operated at its antiresonant frequency,

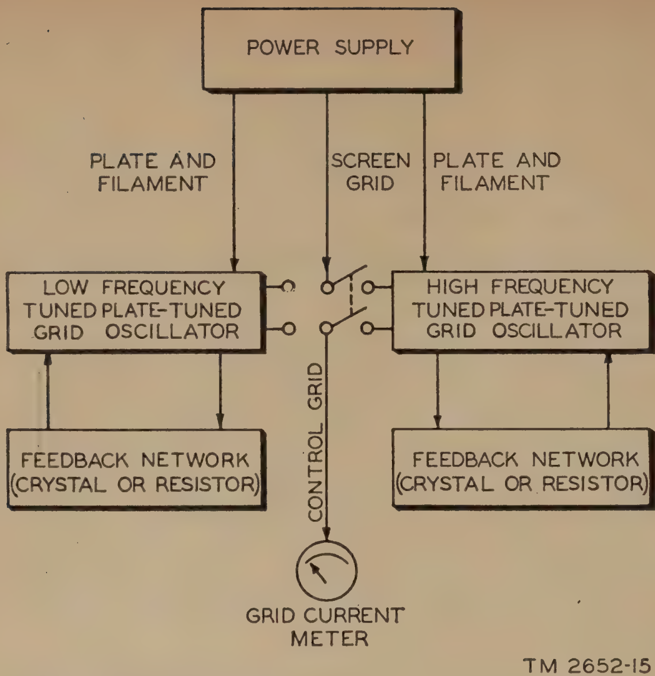

Figure 11. Crystal impedance meter TS–683/TSM, block diagram.

and if the correct value of load capacitance C_1 is connected in series with the crystal unit, the combination of the crystal unit and load capacitance appears as a pure resistance at the correct operating frequency. Therefore, in either case, a resistance may be substituted for the crystal unit or for the combination of crystal unit and load capacitance; this resistance can be adjusted to such a value that the oscillation frequency and amplitude are the same as they were before the substitution was made. This value of resistance is, therefore, the effective series-resonant resistance (R) or the effective antiresonant resistance (R_e).

(3) In actual use, the exact series-resonant or antiresonant frequency may be unknown; this information, however, is not necessary. The circuit of the crystal impedance meter connected to appropriate frequency measuring equipment is tuned first to the approximate frequency; then, by alternate adjustment of the value of the substitution resistance and of the circuit tuning, the correct frequency and value of resistance are obtained. Generally, adjustment must be made only two or three times before satisfaction of the boundary conditions is attained. These adjustments may be compared with the resistance and reactance adjustments performed when balancing an impedance bridge.

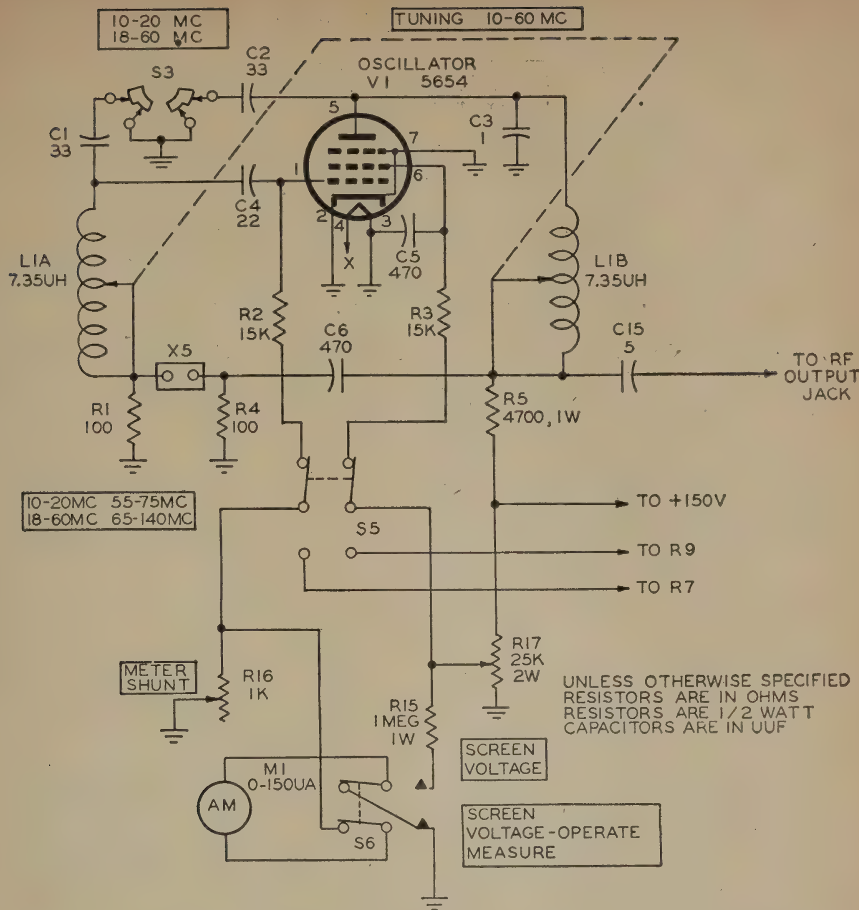

Figure 12. Low-frequency oscillator, simplified schematic diagram.

b. Power Supply.

(1) The power supply (fig. 14) is a conventional type that converts 115 or 230 volts a-c, 50 to 1,000 cps, to the regulated voltage necessary for the plate and screen grid of oscillator tube V1 or V2. The power supply uses rectifier tube V3 (5Y3GT/G) in a full-wave circuit and tube V4 (OA2) as a voltage regulator. A 1-ampere fuse (F1) opens the circuit if an overload or short occurs inside the CI meter. Power ON-OFF switch S1 breaks one side of the a-c line. VOLTAGE CHANGE-OVER switch S2 adapts the unfit for operation on either 115 or 230 volts a-c, 50 to 1,000 cps, by connecting the two halves of the primary winding in parallel or in series.

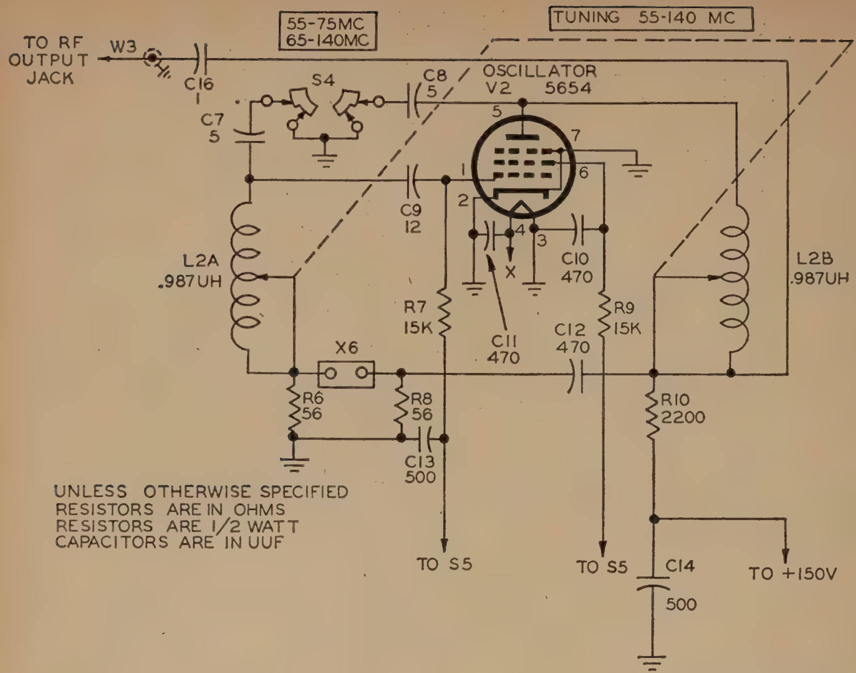

Figure 13. High-frequency oscillator, simplified schematic diagram.

(2) Transformer T1 has a primary rating of 115 or 230 volts a-c, single-phase, with output windings on the secondary of 700 volts at 35 ma (milliampere) center tapped for the plates of V3, 5.0 volts at 3.0 amperes for the filament of V3, and 6.3 volts at 2.5 amperes for the filaments of V1, V2, and pilot lamp E1. The rectified voltage is taken off one side of the filament of rectifier tube V3.

(3) The rectified output of V3 is filtered free of ripple by resistors R11, R12, and R13 and capacitors C17A and C17B. The filter is connected to voltage-dropping resistor R14 which, in turn, is connected to voltage regulating tube V4. Tube V4, operating in conjunction with resistor R14, maintains the voltage across its terminals constant at approximately 150 volts, despite normal changes in line voltage and current drain of the connected circuits. If the voltage across this gaseous regulator rises, the tube will draw more current; this causes a greater voltage drop across R14 and keeps the voltage at the plate (pin 5) of V4 constant. If the line voltage drops because of outside causes, less current will be drawn by tube V4, the voltage across R14 will be smaller, and the voltage at the plate (pin 5) of tube V4 will be constant.

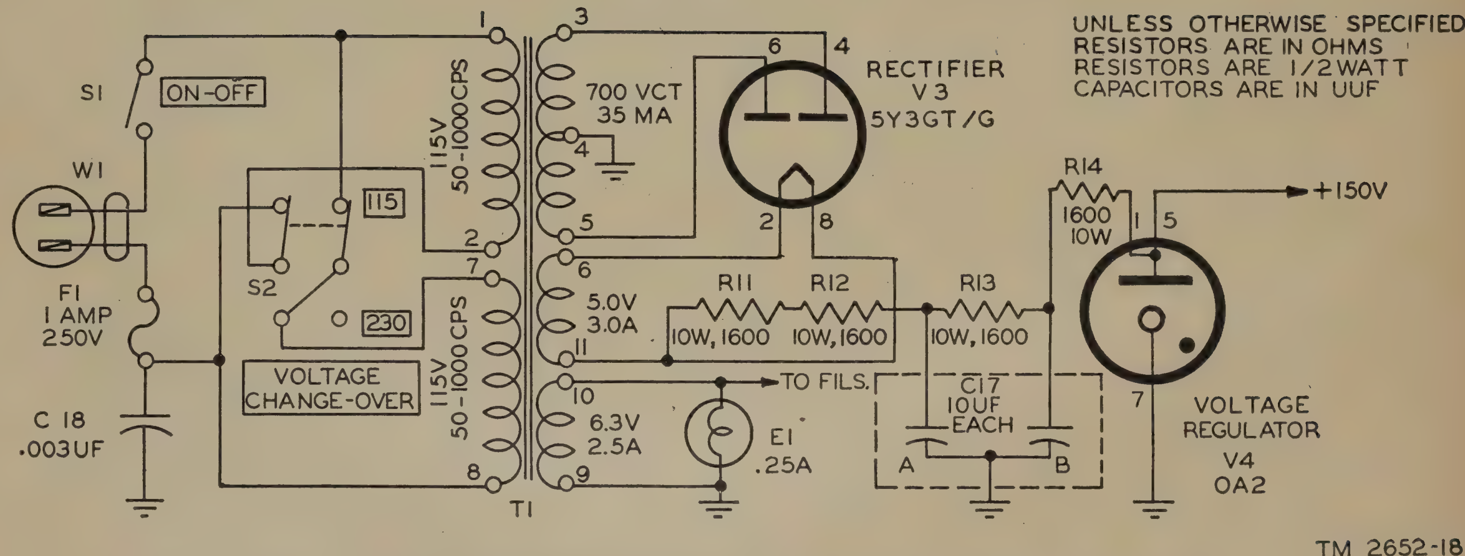

Figure 14. Crystal impedance meter TS-683/TSM, power supply, simplified schematic diagram.

(4) The screen grid of the oscillator tube in use is supplied with d-c (direct-current) voltage controlled by potentiometer R17 (SCREEN VOLTAGE) connected across voltage regulator tube V4. This screen grid voltage controls the amplitude of oscillations. Pilot lamp E1 is operated from the 6.3-volt winding of the secondary of transformer T1. The .003-μf (microfarad) capacitor, C18, bypasses r-f current from the input a-c power line to ground. The 500-$\mu\mu$f capacitor, C14, prevents r-f currents of the plate circuit from flowing in the power supply circuit. A complete schematic diagram is shown in figure 17.

Section II. OSCILLATOR CIRCUIT

49. General

a. The oscillator circuits (figs. 12 and 13) use r-f pentode tubes type 5654 (V1 and V2) operating as class C amplifiers. The feedback path provided by either a crystal or a calibrating resistor converts the amplifier in use to a class C oscillator. The frequency bands (four) are selected with frequency range switch S5 and rotary band switches S3 and S4. Switch S5 connects screen-grid potential to oscillator tube V1 or V2, and also connects the panel microammeter in the grid circuit of the same tube. The other switches, S3 and S4, set the bands covered by the two oscillators. When switch S3, associated with the lower frequency oscillator, is in the 10–20 MC position, capacitors C1 and C2 are connected in parallel with the grid and plate tuning inductors, coil L1A and coil L1B, respectively, to obtain the tuning band specified. When switch S3 is operated to the 18–60 MC position, capacitors C1 and C2 are removed from the circuit, leaving only the circuit-distributed capacitance across grid inductor L1A and the circuit-distributed capacitance plus capacitor C3 across plate inductor L1B. Similarly, when switch S4, associated with the higher frequency oscillator, is in the 55–75 MC position, capacitors C7 and C8 are connected in parallel with the grid and plate tuning inductors L2A and L2B, respectively, to obtain the tuning band specified. When switch S4 is operated to the 65–140 MC position, capacitors C7 and C8 are removed from the circuit. The two oscillator circuits are continuously variable throughout their bands by their tuning controls; TUNING 10–60 MC control drives the low-frequency tuning dial and varies the inductance of coils L1A and L1B, and TUNING 55–140 MC drives the high-frequency tuning dial and varies the inductance of coils L2A and L2B. Output jack J1 (fig. 7) is connected to the plate tuning circuits of the two oscillators through coupling capacitors C15 and C16.

Note. The functioning of the two oscillator circuits is identical except for the frequency bands covered. Therefore, only the functioning of the lower frequency unit will be discussed in detail. For this discussion, it is assumed that frequency range switch S5 has been set to the low position.

b. When the control grid (pin 1) is driven positive during a cycle of oscillation, a rectified current flows through 15,000-ohm grid leak resistor R2 and the grid current meter (the sensitivity of which is adjusted by METER SHUNT potentiometer R16) to ground. Capacitor C4 blocks the rectified control grid current from flowing through the grid tank circuit which consists of r-f variable coil L1A paralleled by the circuit-distributed capacitance for the higher frequency band and with the added capacitance of C1 when S3 is in the lower frequency band position. In the plate circuit of the tube, d-c plate current flows through voltage-dropping resistor R5 and variable tuning inductor L1B to the plate. Coil L1B with its associated capacitance, tracks in frequency with grid coil L1A. The screen-grid positive d-c voltage obtained from potentiometer R17 (SCREEN VOLTAGE), connected across voltage regulator tube V4, controls the amplitude of oscillation. Capacitor C5 bypasses r-f from screen grid to ground. The cathode (pin 2) and the suppressor (pin 7) are connected to ground to reduce the likelihood of output-input circuit feedback through the tube.

c. The higher frequency oscillator, covering the bands 55–75 MC and 65–140 MC, differs from the lower frequency oscillator as follows: a two-section, spiral-type, variable inductance tuner is used. Because of the frequency bands covered, the inductance of tuner coils L2A and L2B is considerably less than the lower frequency coils. Smaller loading capacitors C7 and C8 are shunted across the tuning inductances by switch S4 when operation in the 55–75 MC band is desired. A plate circuit compensating capacitor corresponding to C3 is not required. Grid blocking capacitor C9 is smaller, as are crystal load resistors R6 and R8 and plate voltage-dropping resistor R10. The theory of operation is the same as for the lower frequency oscillator.

50. Feedback Network

When an adequate feedback path is provided and the screen-grid potential is increased to a satisfactory value, the circuit oscillates. The feedback path (figs. 12 and 13) is through crystal socket X5 or X6. This socket also is used when the calibrating resistors are substituted for the crystal being measured. The 470-$\mu\mu$f capacitor, C6, provides a low-impedance path for the r-f voltage developed across resistor R5 by the r-f current generated in the tuned plate tank circuit of tube V1. Capacitor C6 also provides the necessary phase relation for the r-f feedback voltage to the grid circuit. The feedback voltage is injected into the grid circuit across voltage dividing resistor R1.

(Adapter AR–1 is provided with the CI meter. This plugs into crystal socket X5 or X6. It contains a 32.0-$\mu\mu$f capacitor in series with a crystal socket and is used for antiresonant resistance measurements which are made in the same manner as series-resonant resistance measurements—The resistance determined by using the adapter is the approximate antiresonant resistance of the crystal unit operating into a 32.0-$\mu\mu$f load capacitance.) A resistance substitution method is used when making both series-resonant and antiresonant resistance measurements, calibrating resistors (fixed values) in the range between 10 and 150 ohms are plugged into the crystal sockets on the panel. The calibrated resistor selected should give most nearly the same frequency and amplitude of oscillation as the oscillating crystal unit. Amplitude of oscillation is indicated on the grid current meter. The approximate crystal resistance is that of the selected calibrating resistor. The crystal sockets will accommodate any two-pin crystal holder having 0.050-inch pins with 0.486-inch center-to-center spacing.

CHAPTER 6

FIELD MAINTENANCE INSTRUCTIONS

Section I. TROUBLESHOOTING AT FIELD MAINTENANCE LEVEL

Note. This chapter contains information for field maintenance. The amount of repair that can be performed by units having field maintenance responsibility is limited only by the tools and test equipment available, and by the skill of the repairman.

51. Troubleshooting Procedures

Caution: Disconnect all power before making resistance or capacitance checks.

a. General. The first step in servicing a defective CI meter is to sectionalize the faults. Sectionalization means tracing the fault to the *major component or circuit* responsible for the abnormal operation of the meter. The second step is to localize the fault. Localization means tracing the fault to the defective *part* responsible for the abnormal condition. Some faults such as burned-out resistors, r-f arcing, and shorted transformers can often be located by sight, smell, and hearing. The majority of faults, however, must be localized by checking *voltages and resistances.*

b. Component Sectionalization and Localization. The tests listed below aid in isolating the source of trouble. To be effective, the procedure should be followed in the order given. Remember that the servicing procedure should cause no further damage to the equipment. First, localize the trouble to a single circuit. Then isolate the trouble within that circuit by appropriate voltage, resistance, and continuity measurements. The service procedure is summarized as follows:

(1) *Visual inspection.* The purpose of visual inspection is to locate any visible trouble. Through this inspection, the repairman may frequently discover the trouble or determine the circuit in which the trouble exists. This inspection is valuable in avoiding additional damage to the equipment which might occur through improper servicing and in forestalling future failures.

(2) *Input resistance measurements.* These measurements (par. 54) prevent further damage to the equipment from possible short circuits. Since this test gives an indication of the condition of the filter circuits, its function is more than preventive.

(3) *Operational test.* The equipment performance checklist (par. 41) can be used as an operational test. This test is important because it frequently indicates the general location of trouble. In many instances, the information gained will determine the exact nature of the fault. To utilize this information fully, all symptoms must be interpreted in relation to one another.

(4) *Troubleshooting chart.* The trouble symptoms listed in this chart (par. 55*c*) will aid greatly when localizing trouble. The equipment performance checklist (par. 41) also will be found of value in this connection.

(5) *Intermittents.* In all these tests the possibility of intermittents should not be overlooked. If present, this type of trouble often may be made to appear by tapping or jarring the unit.

52. Test Equipment Required for Troubleshooting

The test equipment required for troubleshooting Crystal Impedance Meter TS–683/TSM is listed below. The technical manuals associated with the test equipment also are listed.

Test equipment	Technical manual
Tube Tester I–177–( ), or equivalent	TM 11–2627.
Multimeter TS–352/U, or equivalent	TM 11–5527.

53. General Precautions

Whenever Crystal Impedance Meter TS–683/TSM is serviced, carefully observe precautions listed in *a* through *e* below; careless replacement of parts often causes new faults.

a. Before a part is unsoldered, note the position of the leads. If any part, such as a transformer, has a number of connections, tag each of them.

b. Be careful not to damage other leads by pulling or pushing them out of the way.

c. Do not allow drops of solder to fall into the equipment; they may cause short circuits.

d. A carelessly soldered connection may create a new fault. It is very important to make well soldered joints.

e. When components in the equipment are replaced, they must be placed exactly as the originals. A part which has the same electrical value but different physical size may cause trouble. The leads must be kept the same length as the original wiring.

54. Localizing Trouble in Filament and B+ Circuits

Trouble in Crystal Impedance Meter TS–683/TSM often can be detected by checking the resistance of the filament and high-voltage circuits before applying power to the equipment, thereby preventing damage to the power supply. Disconnect the power cord from the a-c power source. Remove the bottom cover plate. Place all tubes in their sockets. Set Multimeter TS–352/U at a suitable resistance range and measure the resistance between the terminals (*a* below) and ground. If incorrect resistance readings are obtained, check the circuit wiring for anything that might cause a short circuit, such as a metallic chip or a piece of solder. If no short circuits are detected, check the circuit components, such as the filter capacitors and rectifier tube, for shorts or partial shorts. If the correct resistance measurements are obtained, connect the power cord to the a-c power source. Set the multimeter controls for d-c voltage measurements (300 volts or higher) and connect the multimeter test leads to measure the positive d-c voltages between the terminals (*b* below) and ground. If a voltage reading is obtained but the reading is low, turn off the equipment and measure the a-c line voltage. If the line voltage is correct, an unusually high load current is being drawn from the power supply; this load may be caused by defective circuit components. If no voltage indications are obtained, check fuse F1, power ON-OFF switch S1, VOLTAGE CHANGE-OVER switch S2, power transformer T1, and rectifier tube V3.

a. Resistance to Ground.

Component part	Terminal	Resistance to ground (ohms)
V3	4	320.
V3	6	320.
T1	10	0.2.
V1	1	16 K (S5 at low-frequency range; R16 fully clockwise).
V1	5	29 K.
V1	6	40 K (S5 at low-frequency range; R17 fully clockwise).
V2	1	16 K (S5 at high-frequency range; R16 fully clockwise).
V2	5	26 K.
V2	6	40 K (S5 at high-frequency range; R17 fully clockwise).

Note. Measure the d-c resistance of the primary circuit of the power transformer from prong to prong on the a-c plug. With switch S1 closed, the resistance should be about 10 ohms with switch S2 in the 115-volt position and about 40 ohms with S2 in the 230-volt position.

b. Voltage to Ground.

Component	Terminal	Voltage to ground (dc)
V3	2	340.
C17A	+ (pos)	240.
C17B	+ (pos)	185.
V4	1 or 5	150 (tube lighted).
V1	1	−0.15 (S5 at low-frequency range; R16 fully clockwise.)
V1	5	85.
V1	6	83 (S5 at low-frequency range; R17 fully clockwise).
V2	1	−0.10 (S5 at high-frequency range; R16 fully clockwise.)
V2	5	118.
V2	6	85 (S5 at high-frequency range; R17 fully clockwise).

55. Troubleshooting Chart

This chart lists the symptoms which the repairman observes, either visually or audibly, while making a few simple tests. When trouble occurs in the equipment, proceed as follows:

a. Provide for favorable working conditions.

b. Read this manual and study the schematic diagram (fig. 17).

c. Make simple direct preliminary tests such as listed below.

(1) Carefully feel the tubes for filament heat.

(2) Check power source and fuse.

(3) Check method of operation and performance.

(4) Proceed according to the following chart.

Symptom	Possible trouble	Correction
1. Pilot lamp does not light.	*a.* Cord not plugged into a-c source, or open.	*a.* Check at source and meter.
	b. Fuse F1 blown	*b.* Check and replace.
	c. Pilot lamp E1 burned out	*c.* Check and replace.
	d. ON-OFF switch S1 defective.	*d.* Check and replace.
	e. VOLTAGE CHANGE-OVER switch S2 defective.	*e.* Check and replace.
	f. Transformer T1 open	*f.* Check and replace.
2. Pilot lamp lights dimly (on 115 V source).	*a.* VOLTAGE CHANGE-OVER switch S2 set for 230 V.	*a.* Set correctly.
	b. Regulator tube defective	*b.* Check and replace.
Voltage regulator tube V4 does not light.	*c.* Rectifier tube V3 defective.	*c.* Check and replace.
	d. R11, R12, R13, or R14 open.	*d.* Check and replace.
	e. High-voltage winding of T1 open.	*e.* Check and replace.

Symptom	Possible trouble	Correction
	f. Capacitor C17A or C17B shorted.	*f.* Check and replace.
	g. Capacitor C14 shorted	*g.* Check and replace.
3. No apparent reading or deflection of grid current meter (with calibrating resistor in socket).	*a.* Oscillator tube V1 or V2 not oscillating.	*a.* Check and replace. See if tuning dial is within tuning range.
	b. METER SHUNT set too low.	*b.* Turn METER SHUNT control clockwise.
	c. SCREEN VOLTAGE control set too low	*c.* Turn SCREEN VOLTAGE control clockwise.
	d. SCREEN VOLTAGE control defective (open).	*d.* Check and replace.
	e. Wiring shorted or open	*e.* Check continuity.
	f. Meter open, transformer open, or oscillator coil open.	*f.* Check resistances as shown in figure 17. Check voltages as shown in figure 15.
	g. Contact wheel on L1A and L1B not tracking.	*g.* Slide wheels along shafts until they arrive within one-fourth turn of opposite ends of L1A and L1B as traveling stop on tuning shaft reaches locknuts.
4. Oscillates without crystal or calibrating resistor in panel socket.	*a.* Wiring disturbed in feedback or oscillator circuits.	*a.* Restore to their original positions any wires which were disturbed while trouble shooting or repairing.
	b. Tube shield removed	*b.* Replace shield.
	c. Tuning shaft on low-frequency oscillator grounded.	*c.* Remove tuning shaft from ground.
5. Stop on low-frequency tuning does not function.	Locknuts loose	Adjust locknuts to meet requirement in step 3*g* above.

56. Additional Troubleshooting Information

a. D-c and Filament Voltages. Check the d-c and filament voltages on the socket pins of V1 and/or V2. Be sure that controls are properly set and that switch S5 is in the range position corresponding to the oscillator tube socket in use (fig. 15). If voltages appear correct, refer to the schematic diagram (fig. 17) and check the crystal holder networks for wiring continuities or shorts to chassis.

b. D-c Resistance of Transformer. The d-c resistances of transformer T1 should correspond to the following:

Terminals	Ohms
1–2 (with connection to S2 opened)	20
7–8 (with connection to S2 opened)	20
3–4	320
4–5	320

Section II. REPAIRS

57. Replacement of Parts

a. General. When replacenent of a component is necessary because of failure, follow the disassembly procedures given in *d* below. It is assumed that the dust cover and bottom cover plate have been removed during the troubleshooting procedure.

b. Resistors. The resistors are self-supporting. Unsoldering is the only procedure required for removal.

c. Fixed Capacitors. The small capacitors are self-supporting and may be removed by unsoldering. Dual electrolytic capacitor C17 is removed by unsoldering the leads and removing the capacitor mounting nut.

d. Disassembly of Crystal Impedance Meter TS–683/TSM.

(1) Loosen the setscrews on all knobs and remove the knobs from the front panel. Set each dial index over one of the end graduations and record its position. Loosen the setscrews in the dials and remove them from the front panel. Remove the three center screws in each dial plate and lift the dial plates off the front panel.

(2) To remove the microammeter, loosen the stud nuts, take off the wire lugs, and remove the panel screws holding the meter.

(3) To remove the low-frequency range tuning assembly (figs. 8 and 12), unsolder and tag the cabled wires to the coil unit terminal strip. Remove capacitor C15. Remove the dust cover from the tuning assembly. Unscrew the four screws holding the coil assembly to the panel. Note that one of these screws is normally hidden by the dial plate. Remove the retaining nut that secures rotary band switch S3 to the front panel and lift the switch from the panel. The low-frequency tuning assembly now is removable as a unit for replacement or repair.

(4) To remove the high-frequency range tuning assembly, unsolder and tag the cabled wires to the coil unit terminal strip. Remove the three screws that hold the coil assembly

to the panel. Note that one screw is normally hidden by the dial plate. Unscrew the nut that secures rotary band switch S4 to the front panel and remove the switch from the panel.

(5) To remove ON-OFF switch S1, range switch S5, and SCREEN VOLTAGE MEASURE—OPERATE switch S6 from the front panel, remove the respective retaining nut from each switch in the same manner as for switch S3. Unsolder and tag the leads to the SCREEN VOLTAGE and METER SHUNT controls.

(6) Remove the nuts which hold the handles and the four screws which hold the panel to the chassis. The chassis assembly now is removable for repair, if required.

(7) The crystal impedance meter now has been dissasembled to the point where the remaining components can be removed as desired without difficulty.

e. Reassembly Procedure. To reassemble the equipment, reverse the above procedures. Handle the two tuning assemblies carefully to avoid disarranging critical wiring.

Note. Be sure to replace the two dial plates in their original positions as directed in *d* above. Carefully aline the dial plates with the indexes at the previously recorded settings.

58. Refinishing

Refinish repaired or damaged equipment according to applicable Signal Corps specifications. Instructions for refinishing badly marred panels on the exterior of cabinets are given in TM 9–2851.

Section III. ALINEMENT PROCEDURE

59. General

No alinement procedure is necessary for Crystal Impedance Meter TS–683/TSM unless either or both of the tuning assemblies require replacement. Refer to paragraph 57*d* for replacement procedures for either tuning assembly.

60. Equipment Used for Alinement and Adjustment

The alinement of Crystal Impedance Meter TS–683/TSM is established on the higher frequency band of each oscillator unit. For better accuracy, use Frequency Meter TS–174/U (Sig C stock No. 3F4325–174); this meter covers a range of 20 to 280 mc. If the frequency meter is not available, a calibrated receiver may be used. Note that the degree of accuracy obtained will be somewhat lower when using a calibrated receiver instead of the frequency meter. Headphones are needed to check the aural results obtained.

61. Alinement of Crystal Impedance Meter TS–683/TSM

Alinement of this equipment consists of establishing the correct tuning dial setting for a given frequency developed by each oscillator. Basic equipment needed is described in chapter 4. Since the dial calibrations are intended only to be used as rough guides to the frequencies of the oscillators, no arrangement for picking up a standard frequency transmission from WWV is required.

a. Alinement of Low-Frequency Tuning Dial. Connect r-f output cable W5 to output jack J1 on the crystal impedance meter and to the input of Frequency Meter TS–174/U. Connect headphones to the frequency meter audio output. Turn on both units and allow them to warm up for 15 minutes. Position switch S5 on the CI meter to the low-frequency range and rotary band switch S3 to the 18–60 MC position. Insert a 40-ohm calibrating resistor in crystal socket X5. Adjust the screen voltage to 60 volts, by means of the SCREEN VOLTAGE control, with switch S6 held in the SCREEN VOLTAGE MEASURE position. Set the tuning dial on the frequency meter to exactly 60 mc. Slowly vary the tuning control of the crystal impedance meter until a zero beat is heard in the headphones. The dial reading should be 60 mc to within the width of the indicator line. If this agreement is met, check the dial settings at 34 mc (with SCREEN VOLTAGE control at 30 volts) and at 18 mc (with SCREEN VOLTAGE control at 25 volts) against the frequency meter at these frequencies. Tolerance should be within ±3 percent. If the dial on the CI meter is noticeably off at 60 mc, loosen the three center screws slightly and rotate the dial plate until it reads correctly. Tighten the screws when the dial plate is properly positioned. Check the settings at 34 mc and 18 mc. If the dial cannot be made to log at the three frequencies, the contact wheels on coil L1A and coil L1B may not be tracking correctly. Refer to the troubleshooting chart (par. 55) for instructions necessary to correct this condition; then repeat the alinement procedure.

b. Alinement of High-Frequency Tuning Dial. Position switch S5 to the high-frequency range and rotary band switch S4 to the 65–140 MC position. Insert a 100-ohm calibrating resistor in crystal socket X6. Adjust the screen voltage to 130 volts by means of the SCREEN VOLTAGE control. Set the dial of the frequency meter to 110 mc (make sure the dial is set accurately). Slowly vary the tuning control of the crystal impedance meter until a zero beat is heard in the headphones. The dial reading should be 110 mc to within the width of the indicator line. If this condition is met, check the dial settings at 90 mc (with SCREEN VOLTAGE control at 60 volts) and at 65 mc (with SCREEN VOLTAGE control at 35 volts) against the frequency meter at these frequencies. The tolerance should be within ±3 percent. If the dial is noticeably off at 110 mc, rotate the dial plate as described in *a* above. Check the settings at the three test frequencies after the dial

plate is positioned. If the dial cannot be made to log at the three frequencies, the sliding contacts on coils L2A and L2B may not be tacking correctly. If necessary, shift the contacts by lifting them gently with a small screw driver until satisfactory tracking is obtained. Always replace the metal cover on the coil unit when the alinement check is made.

Section IV. FINAL TESTING

62. Equipment Required for Final Testing

The following equipment is necessary for final testing of Crystal Impedance Meter TS–683/TSM:

Frequency meters covering the range from 10 to 140 mc, as given in chapter 4.

Headphones or speaker.

Electronic Multimeter TS–505/U (Sig C stock No. 3F4325–505).

Multimeter TS–352/U (Sig C stock No. 3F4325–352).

63. Tests

The tests below indicate whether a Crystal Impedance Meter TS–683/TSM that has been repaired meets the minimum requirements for satisfactory operation.

a. Visual and Mechanical Inspection. Thoroughly inspect the reconditioned CI meter for loose nuts and screws, mechanical fit, and operation of moving parts, controls, and fastening devices. Check wiring, soldered connections, ground connectors, and finishes for satisfactory workmanship.

b. Continuity Test. Make continuity tests to determine that all circuits are wired properly and that all connections make good electrical contact (par. 54). When satisfied that no shorts exist, turn on the CI meter and measure voltages to ground as outlined in paragraph 54.

c. Dial Calibration. Following the procedure in paragraph 61, check the dial calibration at 60, 34, and 18 mc for the low-frequency oscillator on its higher band and at 20 and 10 mc on its lower band. Similarly, check the dial calibration at 110, 90, and 65 mc for the high-frequency oscillator on its higher band and at 75 and 55 mc on its lower band. The dials should read within ± 3 percent at all specified frequencies. With the stated calibrating resistors in the crystal sockets, oscillation should be obtained throughout the tuning ranges.

d. Amplitude of Oscillation. Plug the 100-ohm calibrating resistor into the low-frequency oscillator crystal socket. Adjust the METER SHUNT control for greatest sensitivity. Using a screen grid voltage up to the maximum, the amplitude of oscillation throughout both tuning bands to 110 mc should be great enough to develop a rectified grid current of at least 30 μa above the normal residual of about 5 to

10 μa. (Measure the residual by removing the calibrating resistor from the crystal jack.) If this requirement cannot be met, replace the oscillator tube. Plug the 100-ohm calibrating resistor into the high-frequency oscillator crystal socket and duplicate the test. The same requirement should be met, but if it cannot be met, replace the oscillator tube.

e. Self Oscillation. With the crystal jack open, neither oscillator should show a rectified grid current above the normal residual value at any point in the tuning bands. A greater current indicates self-oscillation; refer to the troubleshooting chart in paragraph 55 for correction procedures.

CHAPTER 7

SHIPMENT AND LIMITED STORAGE AND DEMOLITION TO PREVENT ENEMY USE

64. Packaging

a. Cushion the set on all surfaces with cells or pads fabricated of corrugated fiberboard.

b. Obtain the proper amount of desiccant, as prescribed in TM 38–230, and place the cushioned set, together with technical manuals and desiccant, within a close-fitting, regular slotted style, corrugated fiberboard box.

c. Seal the entire closure with gummed Kraft tape and blunt all corners of the box.

d. Place the boxed set within a moisture-vaporproofed barrier, type 1, and heat-seal the closure.

e. Place the moisture-vaporproofed set within a second close-fitting regular slotted style corrugated fiberboard box and seal the entire closure with water-resistant tape or adhesive.

f. Overwrap the boxed set in waterproof barrier material, type L–2 or M.

g. Completely seal all joints, seams, and closures with adhesive or other suitable seal equal in moisture resistance to that of the body material in accordance with approved specifications.

65. Packing and Marking

Materials used in packing, as described in the following subparagraphs, should comply with the requirements in joint Army-Navy specification JAN–P–100.

a. Place the packaged equipment within a nailed wooden box lined with a 2-inch thickness of excelsior compacted to 3 pounds per cubic foot. The shipping container should not be lined with a waterproof bag.

b. For oversea shipment only, the shipping container should be strapped in accordance with approved techniques.

66. Methods of Destruction

a. Smash. Smash the crystals, controls, tubes, coils, switches, capacitors, and transformers; use sledges, axes, pickaxes, hammers, crowbars, or other heavy tools.

b. Cut. Cut all cords, cables, and wiring; use axes, handaxes, or machetes.

c. Burn. Burn cords, resistors, capacitors, coils, wiring, and technical manuals; use gasoline, kerosene, oil, flame throwers, or incendiary grenades.

d. Bend. Bend chassis, control connections, and tube clamps.

e. Explosives. If explosives are necessary, use firearms, grenades, or TNT.

f. Disposal. Bury or scatter the destroyed parts in slit trenches, fox holes or other holes, or throw them into streams.

g. Destroy. Destroy everything.

APPENDIX I

REFERENCES

Note. For availability of items listed, check SR 310–20–3, SR 310–20–4, SR 310–20–5, and SR 310–20–21.

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1. Army Regulations

AR 380–5	Military Security (Safeguarding Security Information).
AR 750–5	Maintenance of Supplies and Equipment (Maintenance Responsibilities and Shop Operation).

2. Supply

SB 11–100	Serviceability Standards for Signal Equipment in Hands of Troops.
SR 725–405–5	Issue of Supplies and Equipment, Preparation and Submission of Requisitions for Signal Corps Supplies.

3. Auxiliary Equipment and Test Equipment

TM 11–300	Frequency Meter Sets SCR–211–A, B, C, D, E, F, J, K, L, M, N, O, P, Q, R, T, AA, AC, AE, AF, AG, AH, AJ, AK, AL, and AN.
TM 11–850	Radio Receivers BC–312–(*), BC–314–(*), BC–342–(*), BC–344–(*), and Radio Receiver Assemblies OA–65/MRC–2, and OA–65A/MRC–2.
TM 11–2530	Frequency Standard TS–308/U.
TM 11–2540	Quartz Crystals; Theory, Fabrication, and Performance Measurements.
TM 11–2606	Test Set AN/FSM–3, Tool Equipment TK–40/FSM–3, and Maintenance Kit MK–40/FSM–3 (Formerly Depot Crystal Equipment AN/FSM–1).

TM 11–2627 ----- Tube Tester I–177 and I–177–A.
TM 11–4700 ----- Electrical Indicating and Measuring Instruments; Repair Instructions.
TM 11–5511 ----- Electronic Multimeter TS–505/U.
TM 11–5527 ----- Multimeter TS–352/U.

4. Painting, Preserving, and Lubrication

TB SIG 13 ------ Moistureproofing and Fungiproofing Signal Corps Equipment.
TB SIG 69 ------ Lubrication of Ground Signal Equipment.
TM 9–2851 ------ Painting Instructions for Field Use.

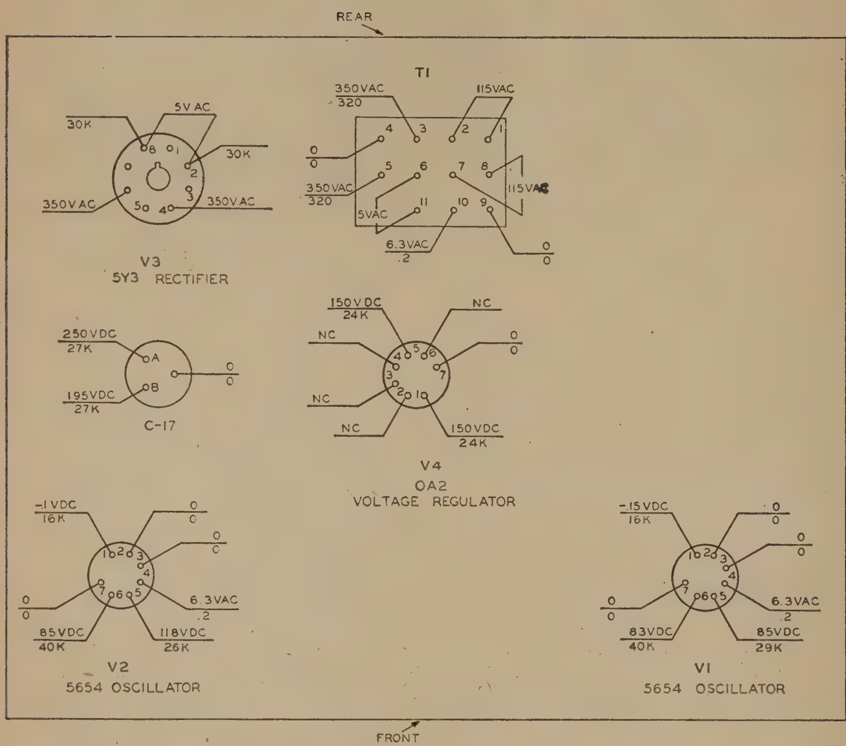
5. Camouflage, Decontamination, and Demolition

FM 5–20 --------- Camouflage, Basic Principles.
FM 5–25 --------- Explosives and Demolitions.
TM 3–220 -------- Decontamination.

6. Other Publications

FM 24–5 --------- Signal Communications.
SR 310–20–3 ----- Index of Training Publications.
SR 310–20–4 ----- Index of Technical Manuals, Technical Regulations, Technical Bulletins, Supply Bulletins, Lubrication Orders, and Modification Work Orders.
SR 310–20–5 ----- Index of Administrative Publications.
SR 700–45–5 ----- Unsatisfactory Equipment Report (Reports Control Symbol CSGLD–247).
SR 745–45–5 -----; Navy Shipping Guide Article 1850–4.; AFR 71–4 -------- Report of Damaged or Improper Shipment (Reports Control Symbols CSGLD–66 (Army), SandA-70-6 (Navy), and AF–MC–U2 (Air Force)).
TB SIG 25 ------- Preventive Maintenance of Power Cords.
TB SIG 66 ------- Winter Maintenance of Signal Equipment.
TB SIG 72 ------- Tropical Maintenance of Ground Signal Equipment.
TB SIG 75 ------- Desert Maintenance of Ground Signal Equipment.
TB SIG 178 ------ Preventive Maintenance Guide for Radio Communication Equipment.
TB SIG 219 ------ Operation of Signal Equipment at Low Temperatures.
TM 11–455 ------- Radio Fundamentals.
TM 11–483 ------- Suppression of Radio Noises.

TM 11-486	Electrical Communication Systems Engineering.
TM 11-660	Introduction to Electronics.
TM 11-661	Electrical Fundamentals (Direct Current).
TM 11-676	Grounding Procedure and Protective Devices.
TM 11-681	Electrical Fundamentals (Alternating Current).
TM 11-4000	Trouble Shooting and Repair of Radio Equipment.
TM 11-5051	Crystal Impedance Meter TS-330/TSM.
TM 11-5052	Crystal Impedance Meter TS-537/TSM.
TM 38-230	Preservation, Packaging, and Packing of Military Supplies and Equipment.

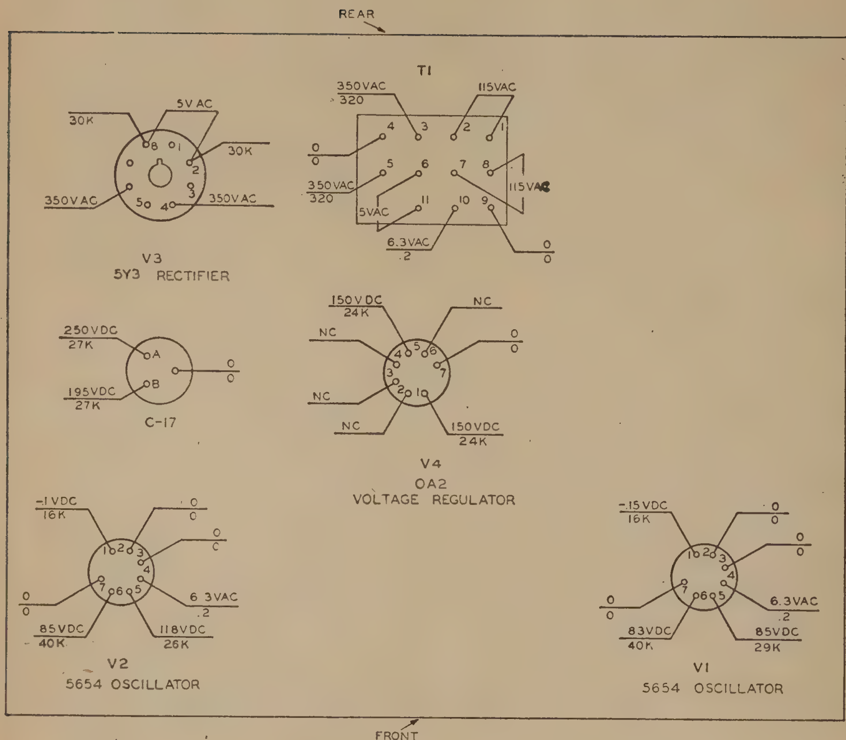


NOTES:

1. INPUT 115VAC
2. READINGS TAKEN TO GROUND UNLESS INDICATED.
3. 20 000 OHMS-PER-VOLT MULTIMETER USED FOR READINGS.
4. UNIT NON-OSCILLATING DURING MEASUREMENTS
5. SCREEN VOLTAGE CONTROL FULL CLOCKWISE.
6. S5 IN 10-20MC, 18-60MC POSITION FOR V1; IN 55-75MC, 65-140MC POSITION FOR V2 READINGS.
7. POWER ON FOR VOLTAGE READINGS, OFF FOR RESISTANCE MEASUREMENTS.
8. RESISTANCES ARE IN OHMS.

TM 2652-19

Figure 15. Component terminal voltage and resistance diagram.



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TM 2652-19

Figure 15. Component terminal voltage and resistance diagram.

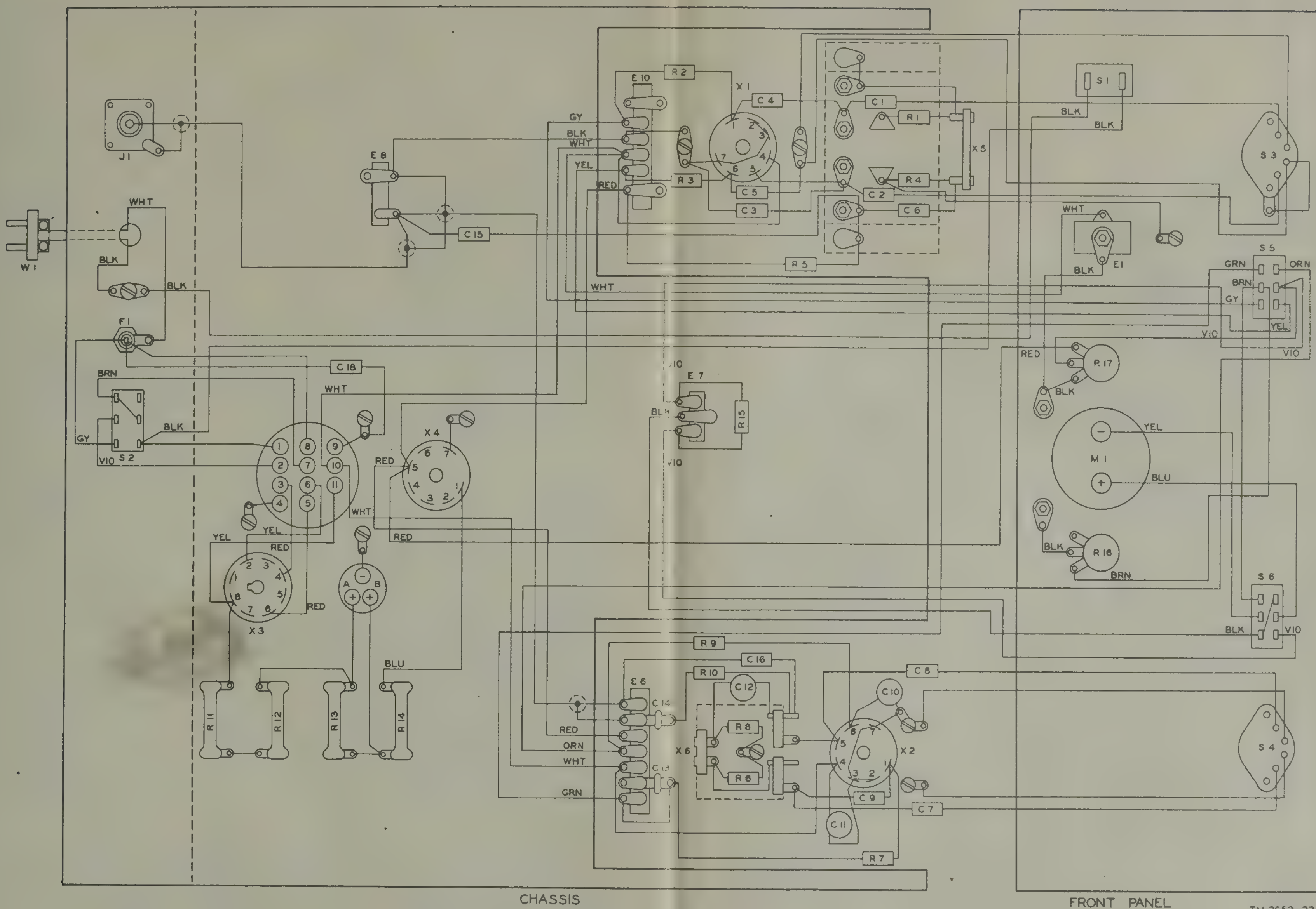
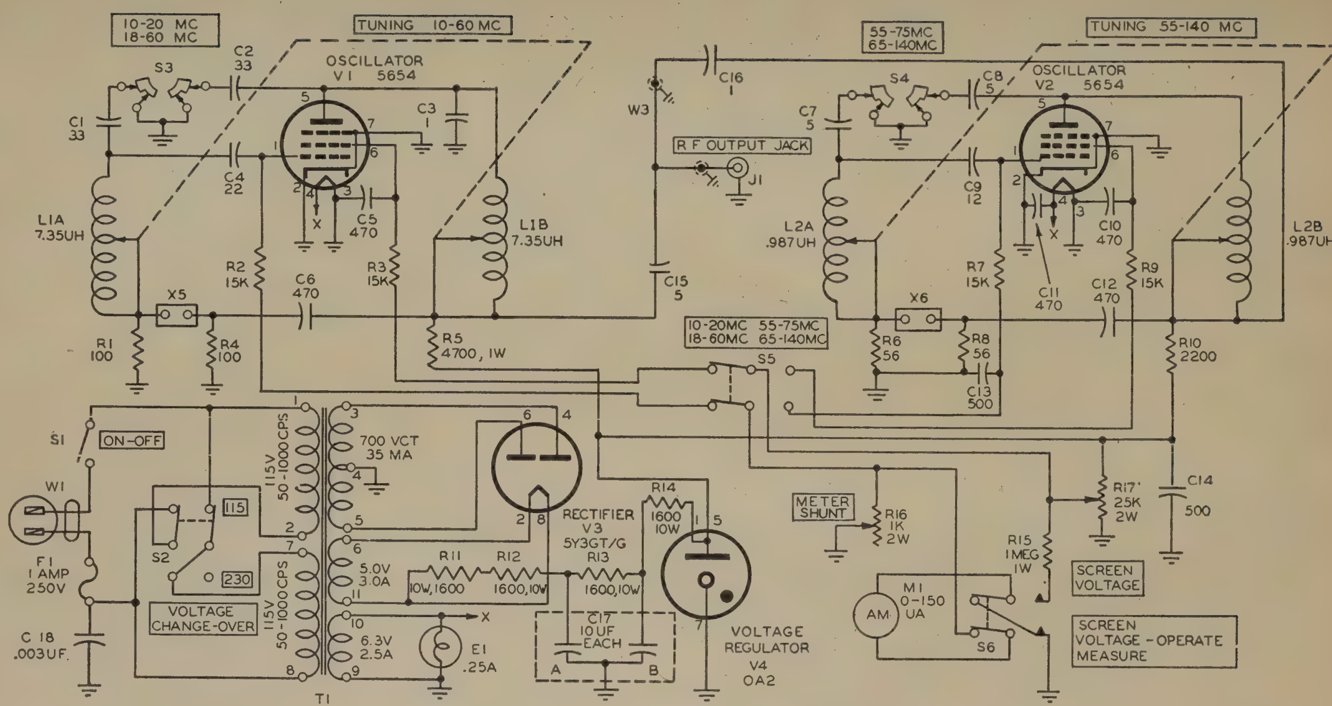


Figure 16.—Crystal impedence meter TS–683/TSM, wiring diagram.



NOTES:

1. UNLESS OTHERWISE NOTED:
   RESISTORS ARE IN OHMS
   RESISTORS ARE 1/2 WATT
   CAPACITORS ARE IN UUF
2. SWITCHES ARE VIEWED FROM END OPPOSITE CONTROL KNOB.
3. SWITCH S3 IN "10-20MC" POSITION
4. SWITCH S4 IN "55-75MC" POSITION

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Figure 17. Crystal Impedance meter TS-683/TSM, schematic diagram.

APPENDIX II

IDENTIFICATION TABLE OF PARTS

Note. The fact that an item appears in this table is not sufficient basis for requisitioning the item. Requisitions must cite an authorized basis, such as a specific T/O & E, T/A, SIG 7 & 8, list of allowances of expendable material, or another authorized supply basis. The Department of the Army Supply Manual applicable to the equipment covered in this manual is SIG 7 & 8–TS–683/TSM. See SR 310–20–21, Index of Signal Corps Supply Manuals. The Signal Corps stock number for Crystal Impedance Meter TS–683/TSM is 3F4314–3.2.

Ref. symbol	Name of part and description	Function of part	Signal Corps stock No.
	ADAPTER, test	Used as antiresonance adapter	2Z307–132
	ADAPTER, test	Used as calibrating resistor	2Z307–131
M1	AMMETER: D-C; range 0–150 μa	Measures grid current or screen voltage	3F871E5–13
W6	CABLE, power, electrical: 2 cond, stranded, #16 AWG, rubber insulation.	Power cord	1B3016–2.24
W2	CABLE, RF: uhf cable; coaxial; 52-ohm characteristic impedance; 4000 v rms max operating voltage.	R-f output cable	1F425–8A
C1, C2	CAPACITOR, fixed: ceramic dielectric; 33 μμf capacity, 500 vdcw.	C1: Tuning capacitor for grid circuit of V1 C2: Tuning capacitor for plate circuit of V1.	3D9033–46
C3, C16	CAPACITOR, fixed: ceramic dielectric; 1 μμf capacity, 500 vdcw.	C3: Adjust tracking of plate circuit of V1 C16: Output coupling capacitor.	3D9001–15
C4, C20	CAPACITOR, fixed: ceramic dielectric; 22 μμf capacity, 500 vdcw.	C4: Couples grid of V1 to tuning circuit C20: Load capacitor; part of antiresonance adapter.	3D9022–27
C7, C8	CAPACITOR, fixed: ceramic dielectric; 5 μμf capacity, 500 vdcw.	C7: Tuning capacitor for grid circuit of V2 C8: Tuning capacitor for plate circuit of V2.	3D9005–84
C9	CAPACITOR, fixed: ceramic dielectric; 12 μμf capacity, 500 vdcw.	Couples grid of V2 to tuning circuit	3D9012–56
C10, C11, C12	CAPACITOR, fixed: ceramic dielectric; 470 μμf capacity, 600 vdcw.	C10: Bypasses r-f from screen grid of V2 to ground. C11: Bypasses r-f from filament of V2 to ground. C12: Couples plate and grid circuits of V2 in feedback loop.	3D9470–46
C15	CAPACITOR, fixed: ceramic dielectric: 5 μμf capacity, 500 vdcw.	Output coupling capacitor	3D9005–84
C17	CAPACITOR, fixed: electrolytic; 2 sect.; 10 μf capacity per sect.; 450 vdcw.	Filters output of V3	3DB10–168

Ref. symbol	Name of part and description	Function of part	Signal Corps stock No.
C18	CAPACITOR, fixed: paper dielectric; 3000 $\mu\mu f$, 600 vdcw.	Bypasses r-f from a-c power line	3DA3-133
C19	CAPACITOR, variable: ceramic dielectric; rotary type; 1 sect.	Part of antiresonance adapter	3D9012V-25
C5, C6	CAPACITOR, fixed: mica dielectric; 470 $\mu\mu f$ capacity, 500 vdcw.	C5: Bypasses r-f from screen grid of V1 to ground. C6: Couples plate and grid circuits of V1 in feedback loop.	3K2047142
C13, C14	CAPACITOR, fixed: mica dielectric; 500 $\mu\mu f$ capacity, 500 vdcw.	C13: R-f bypass for meter M1. C14: Keeps r-f out of power supply.	3D9500-195
H2	CLAMP, electrical: SS; cap type	Holds V3 in socket	2Z2642.442
P1	CONNECTOR, plug: male	Connects r-f cable to CI meter	2Z308-573
P2	CONNECTOR, plug: 2 cont; male	Power cable plug	6Z1727
J2, J3	CONNECTOR, receptacle: 1 cont, female; banana type connector.	Ground connection	
J1	CONNECTOR, receptacle: 1 cont, female, round	Connects r-f cable assembly to CI meter	2Z308-568
V1, V2	ELECTRON TUBE: pentode; 7 terminations	Oscillator tube	2J5654/6AK5W
V3	ELECTRON TUBE: diode; 5 terminations	Full-wave rectifier	2J5Y3GT
V4	ELECTRON TUBE: diode; 7 terminations	Voltage regulator	2JOA2
F1	FUSE, cartridge: 1 amp, 250 v	Line fuse	3Z1926
E2	FUSEHOLDER: extractor post type; 125 v, 15 amp	Holds line fuse	3Z3285-6. 7
E11	HOLDER, resistor: plug type; accom and contains a resistor.	Calibrating resistor	3Z6001-158
E12	HOLDER resistor: plug type; accom and contains a resistor.	Calibrating resistor	3Z6002B2-32
E13	HOLDER, resistor: plug type; accom and contains a resistor.	Calibrating resistor	3Z6003-83

E14	HOLDER, resistor: plug type; accom and contains a resistor.	Calibrating resistor	3Z6004-59
E15	HOLDER, resistor: plug type; accom and contains a resistor.	Calibrating resistor	3Z6005A1-24
E16	HOLDER, resistor: plug type; accom and contains a resistor.	Calibrating resistor	3Z6006-52
E17	HOLDER, resistor: plug type; accom and contains a resistor	Calibrating resistor	3Z6006H8-22
E18	HOLDER resistor: plug type; accom and contains a resistor.	Calibrating resistor	3Z6008B2-22
E19	HOLDER, resistor: plug type; accom and contains a resistor.	Calibrating resistor	3Z6009A1-8
E20	HOLDER, resistor: plug type; accom and contains a resistor.	Calibrating resistor	3Z6010-267
E21	HOLDER, resistor: plug type; accom and contains a resistor.	Calibrating resistor	3Z6012-38
E22	HOLDER, resistor: plug type; accom and contains a resistor.	Calibrating resistor	3Z6015-126
	KNOB: bakelite	Adjusts switch S3	2Z5822-600
	KNOB: round; plastic; black	Tuning knob for low-frequency oscillator	2Z5822-630
	KNOB: round; plastic; black	Control knob for R16	2Z5822-385
E1	LAMP, incandescent: 6-8 v, .25 amp; miniature bayonet; clear; white.	Indicates if unit is on	2Z5927
I1	LIGHT, panel: 1 lamp, miniature bayonet base, 6-8 v; jewel assembly, burnished nickel, all other parts cadmium.	Holds pilot lamp	2Z5991
	OSCILLATOR, RF: 10-60 mc range, 2 bands; tuned plate—tuned grid circuit; a-c, 6.3 v, 60 cyc, single ph, 1.1 va; d-c, 150 v, 13 ma.	Low-frequency oscillator	2C2711-17
	OSCILLATOR, RF: 55-140 mc range, 2 bands; tuned plate—tuned grid circuit; a-c, 6.3 v, 60 cyc, single ph, 1.1 va; d-c, 150 v, 13 ma.	High-frequency oscillator	2C2711-18

Ref. symbol	Name of part and description	Function of part	Signal Corps stock No.
	OSCILLATOR SUBASSEMBLY: c/o; 1 rh coil, 1 lh coil, 1 center shaft, 1 right side shaft, 1 left side shaft.	Oscillator tuning coil assembly	2C2798–19
R15	RESISTOR, fixed: 1 meg; 1 w	Meter M1 multiplier resistor	3Z6801–122
R1, R4	RESISTOR, fixed: comp; 100 ohms; ½ w	Crystal load resistor.	
R2, R3, R7, R9	RESISTOR, fixed: comp; 15,000 ohms; ½ w	R2: Grid leak resistor for V1; R3: screen voltage-dropping resistor; R7: Grid leak resistor for V2; R9: Screen voltage-dropping resistor for V2.	3RC20BF153J
R6, R8	RESISTOR, fixed: comp; 56 ohms; ½ w	Crystal load resistor	3RC20BF560J
R10	RESISTOR, fixed: comp; 2200 ohms; ½ w	Drops r-f in tuned plate circuit of V2	3RC20BF222J
R5	RESISTOR, fixed: comp; 4700 ohms; 1 w	Drops r-f in tuned plate circuit of V1	3RC30BF472J
R11, R12, R13, R14	RESISTOR, fixed: WW; 1600 ohms; 10 w	R11, R12, R13: Filter output of V3; R14: Filters output of V3 and regulates plate voltage of V1 and V2	
R16	RESISTOR, variable: 1000 ohms; 2 w nominal power rating.	Adjusts sensitivity of meter M1	3RV31018
R17	RESISTOR, variable: 25,000 ohms; 2 w nominal power rating.	Adjusts screen voltage of V1 and V2	3RV42524
R18	RESISTOR, variable: comp; 100 ohms	Part of calibrating resistor	3RV21015
E3, E4	SHIELD, electron tube: brass, cad pl; cyl; bayonet base, locking type.	E3: Shield for tube V1; E4: Shield for tube V2	2Z8304.57
E5	SHIELD, electron tube: brass, cad pl; cyl; bayonet base, locking type.	Shield for tube V4	2Z8304.172
X1, X2, X4	SOCKET, electron tube: 7 cont; beryllium-copper; silver pl.	X1: Socket for tube V1; X2: Socket for tube V2; X4: Socket for tube V4.	2Z8677.99
X3	SOCKET, electron tube: 8 cont; beryllium-copper; silver pl.	Socket for tube V3	2Z8678.327

X5, X6, X7	SOCKET, crystal: .050″ dia pins accom; .486″ spacing c to c.	Crystal sockets	2Z8761-60
S1	SWITCH, toggle: single pole, single throw; 15 amp; 125 v a-c.	Power ON and OFF switch	3Z9863-42A
S2, S5	SWITCH, toggle: double pole, double throw; 25 amp; 125 v a-c.	Select power transformer T1 primary voltage, 115 or 230 volts.	3Z9863-52N
S6	SWITCH, toggle: double pole, double throw; 15 amp; 125 v a-c.	Connects meter M1 to grid or screen circuits	3Z9863-52R
S3, S4	SWITCH, rotary: 2 sect.; 6 positions; 6 v, 1 amp	S3: Adjusts frequency range of low frequency oscillator; S4: Adjusts frequency range of high frequency oscillator.	3Z9825-58.217
T1	TRANSFORMER, power: stepdown and stepup; 115/230 v a-c; 50 to 1720 cyc; single ph.	Power transformer	2Z9621-381
	TUNER, RF: 30 to 300 mc; 2 bands	Variable inductor for oscillator	2ZW152-25

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[AG 413.44 (10 Nov 53)]

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